GROUND WATER IN INDIANA

by

Marshall Harrell

Publication No. 133, 1935

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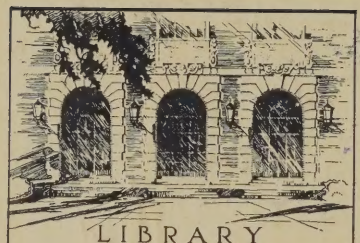

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GROUND WATER IN INDIANA

BY

MARSHALL ALLEN HARRELL

Submitted in partial fulfillment of
the requirements for the degree,
Doctor of Philosophy, in the
Department of Geology in
the Graduate School of
Indiana University,
June 1933

PRELIMINARY REPORT

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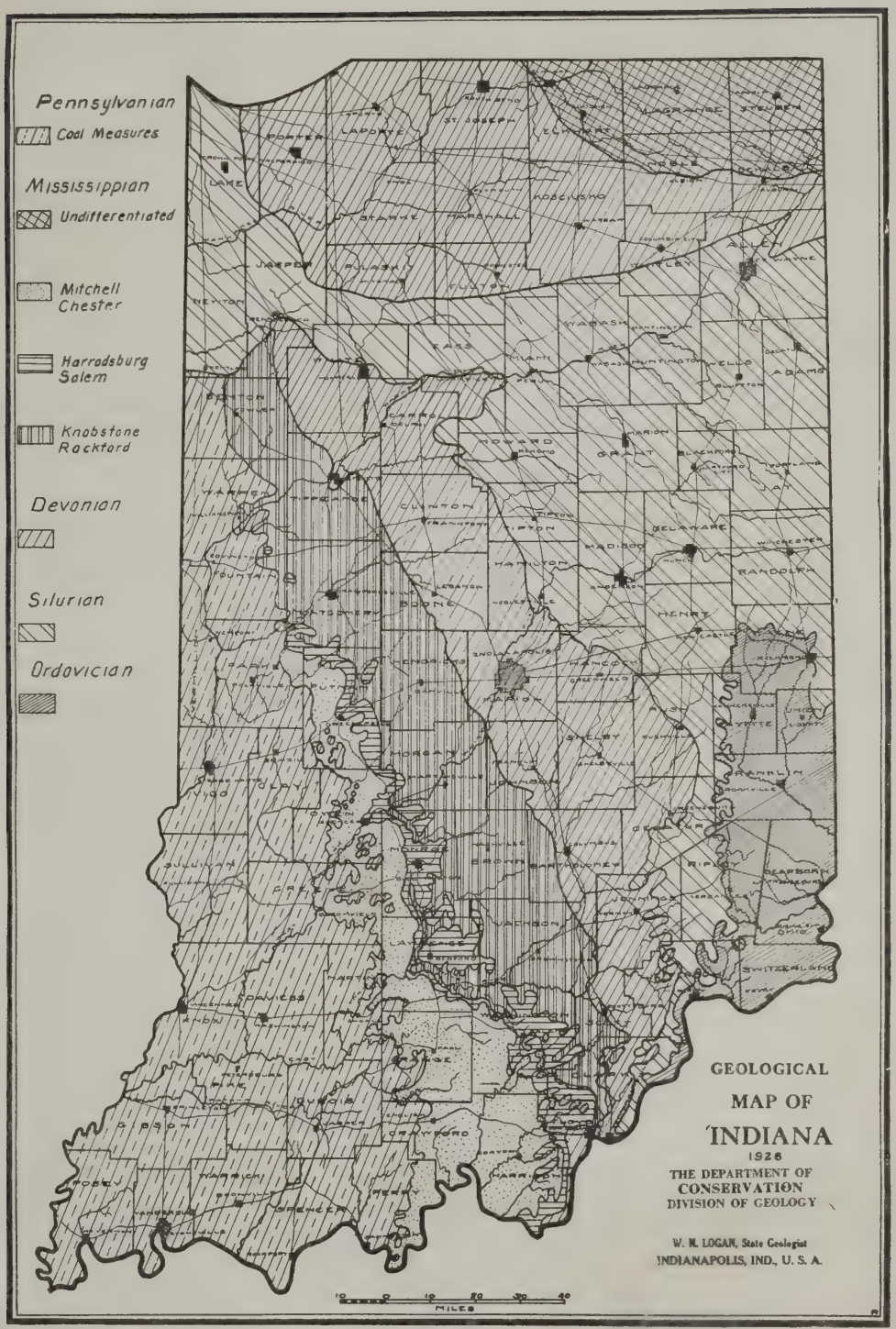
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Mississippian
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Ordovician
GEOLOGICAL
MAP OF
INDIANA
1926
THE DEPARTMENT OF
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W. N. LOGAN, State Geologist
INDIANAPOLIS, IND., U. S. A.
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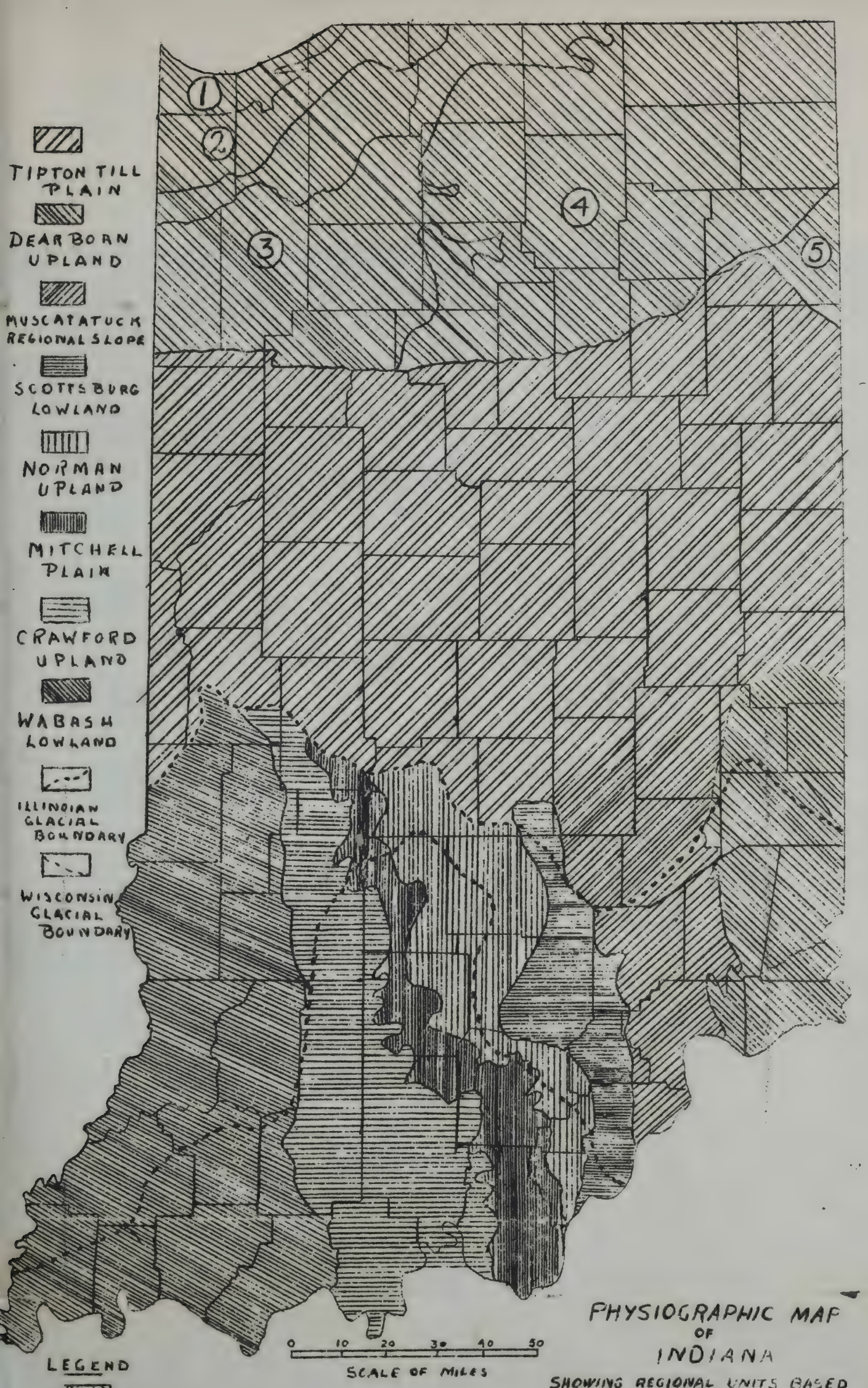


PHYSIOGRAPHIC MAP OF INDIANA

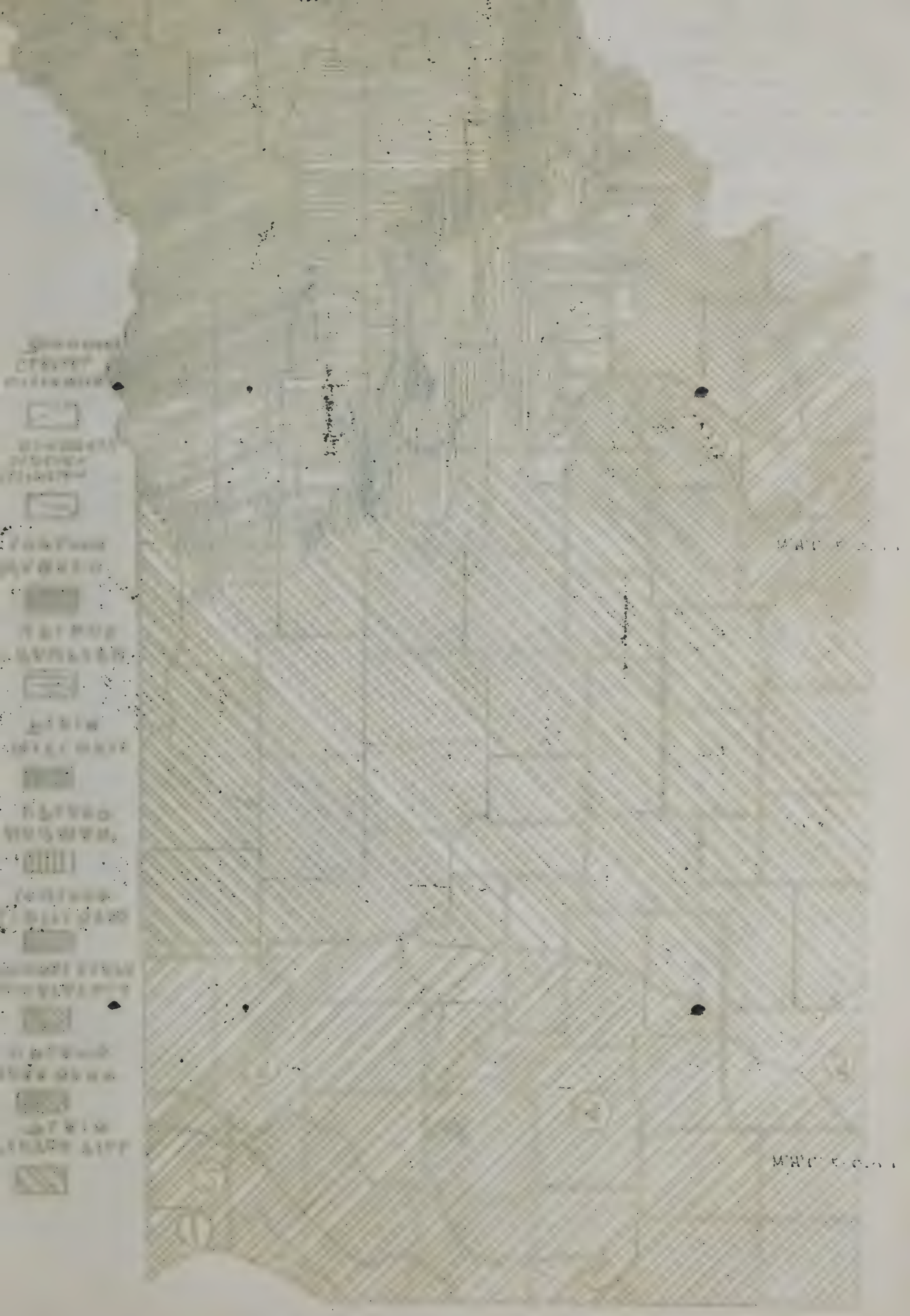
SHOWING REGIONAL UNITS BASED CHIEFLY ON TOPOGRAPHIC CONDITION

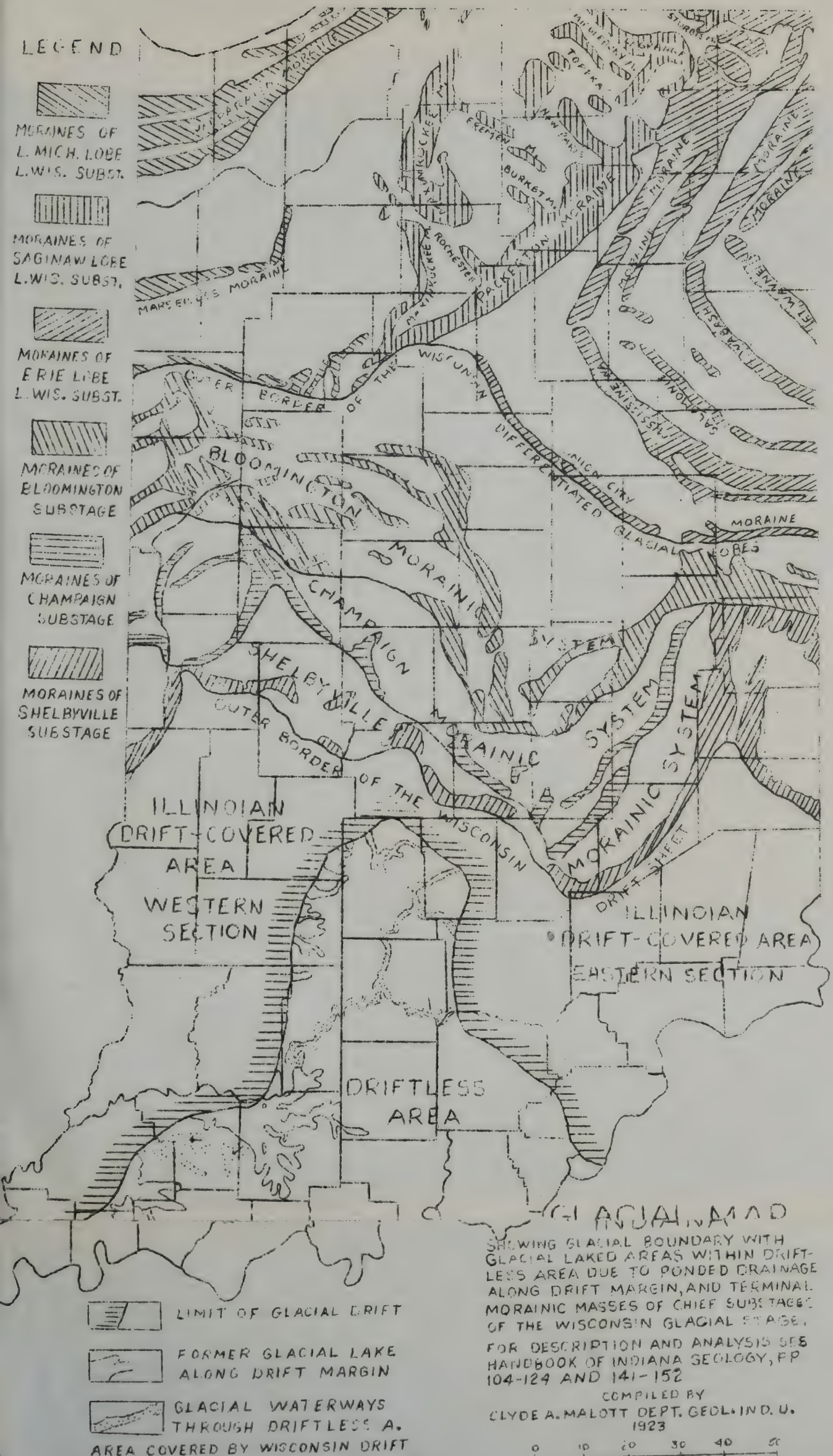
AS DEFINED AND DESCRIBED IN THE HANDBOOK OF INDIANA GEOLOGY PP 83-124, 155, 158-159, 166-169, 173, 187-189, 215-218, AND 244-255.

BY

CLYDE A. MALOTT, DEPT. GEOL., IND. UNIV.

1923.

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MORAINES OF SAGINAW LOBE L. WIS. SUBST.
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DRIFT SHEET
MARSEILLES MORAINE
ROCHESTER
PACKERTON
TOPEKA
LIMIT OF GLACIAL DRIFT
FORMER GLACIAL LAKE ALONG DRIFT MARGIN
GLACIAL WATERWAYS THROUGH DRIFTLESS A.
AREA COVERED BY WISCONSIN DRIFT IN INDIANA EQUALS 22,900 SQ. MI.
0 10 20 30 40 50
SCALE OF MILES

GLACIAL MAP

SHOWING GLACIAL BOUNDARY WITH GLACIAL LAKED AREAS WITHIN DRIFTLESS AREA DUE TO PONDED DRAINAGE ALONG DRIFT MARGIN, AND TERMINAL MORAINIC MASSES OF CHIEF SUBSTAGES OF THE WISCONSIN GLACIAL STAGE.

FOR DESCRIPTION AND ANALYSIS SEE HANDBOOK OF INDIANA GEOLOGY, PP 104-124 AND 141-152

COMPILED BY
CLYDE A. MALOTT DEPT. GEOL. IND. U.
1923

GROUND WATER IN INDIANA

BY MARSHALL ALLEN HARRELL

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

Water is the most valuable of the mineral resources. The study of ground waters is therefore clearly within the field of economic geology and constitutes an important part of the work of geological surveys. The various state and Federal surveys recognized this fact many years ago. A total of 640 Water-Supply Papers has been issued by the United States Geological Survey. Many of these reports were issued in cooperation with various state surveys. The ground waters of the State of Indiana were investigated by Frank Leverett in the 1890's during the course of his glacial investigations. He secured a large body of data bearing on water supply and the United States Geological Survey published this information in Water-Supply and Irrigation Papers Numbers 21 and 26. These were published in 1899. In 1907, the United States Geological Survey again undertook a study of the underground waters of north-central Indiana. Mr. Stephen R. Capps was assigned to this work and 19 counties were covered. The study was published as Water-Supply Paper Number 254, in 1910. The United States Geological Survey also published a paper by Frank Leverett, "Water Resources of Indiana and Ohio," in the 18th Annual Report, Part IV, 1897. In addition to these reports by the Federal Survey, the earlier reports of the Indiana Department of Geology and Natural Resources contain scattered facts relating to the general subject of ground water.

The present report is a summary and condensation of facts relating to the conditions of ground water occurrence throughout the State of Indiana. It is essentially an inventory of the principal sources and the occurrence of ground waters of the State. In addition an attempt is made to establish some general principles of the occurrence of ground waters in Indiana in the hope that urban, rural and industrial enterprises having need of the ground water resources may be aided in their searches and developmental projects. It is hoped that problems of local development may obtain an adequate foundation for their solution, though the time given to the study was insufficient to make an exhaustive field study of every community within the State.

The purpose of this investigation, in brief, is to determine to the fullest extent, with the time and funds available, the significant facts regarding ground water in Indiana. This statewide project was conceived by Dr. W. N. Logan, State Geologist, and actual work of collecting information was instituted in 1919. It was not possible, nor was it feasible to attempt an early completion of a

report bearing on ground waters of the State. The work could not be pursued except incidentally to other duties of the State Geologist and his summer field parties.

The need of a scientific investigation of the ground water resources of Indiana is evident to all who consider the matter. For a period of fifty years, the State of Indiana has had a ten per cent increase in population every ten years. Reports of 1931 of the Indiana State Board of Health show that of the 524 incorporated cities and towns in Indiana, only 280 were equipped with public water supplies. Many towns are considering the installation of new water supplies, and still others are seeking better and more adequate supplies. Of the 280 towns and cities with public water supplies, a total of 232 obtain their water supplies from ground water. According to the Census of 1930, Indiana's rural population is 43 per cent of the total. Citizens in rural localities must depend on ground water supplies or artificial reservoirs and cisterns. Stream or lake water could be used in a few instances, but is not desirable. We have no record of the percentage of population in urban groups which is dependent upon private ground water supplies. It is a fact that many private wells are in use in cities and many homes and individuals secure water therefrom. When this latter fact is considered with Indiana's 43 per cent rural population, it is obvious that ground water plays a very prominent role in water supply.

The problems which arise in connection with water supplies are numerous. In some parts of the State there are serious difficulties in obtaining a suitable supply and ground water can not be secured for adequate supplies everywhere in Indiana. It is believed that careful interpretation of data from wide areas, a knowledge of the geologic structure, and an acquaintance with the occurrence, distribution and movement of ground waters are necessary for the best solution of such problems. The statement of the facts and the discussion of the conditions as presented in this paper should be of benefit to various municipalities of the State, to individuals, and in particular to well drillers or men actively engaged in the search for water supplies.

It is to be regretted that we do not have on file the record of thousands of deep wells drilled in Indiana in search of oil and gas. Since June 1919, it has been mandatory for oil and gas operators and drillers to send to the Division of Geology of the Department of Conservation copies of all deep well records. We are indebted to those individuals who have met with both the spirit and letter of the ruling. It is from the many well logs that we have secured much information concerning the deeper water horizons. It is to be hoped that a similar ruling in regard to ordinary water wells will be inaugurated and that a detailed record will be available in the future which will show the facts pertaining to each well penetrating as much as 50 feet or more in depth.

The Indiana Well Drillers Association was organized in 1930 for the purpose of advancing the work of well drilling in the State through increased knowledge of the occurrence and character of the ground waters and through better methods of recovering them.

ACKNOWLEDGEMENTS

It is recognized that any study of ground water involves details which are cumulative. Adequate investigation of an area the size of the State of Indiana would consume years of one individual's time. Also such a study is largely a cooperative undertaking and the writer has had to depend on facts and figures as given by well drillers and residents throughout the region. In addition, the already published information has been drawn on repeatedly. The writer wishes to record his indebtedness to the publications which have a bearing on Indiana geology and ground water of Mr. Frank Leverett, Mr. Stephen R. Capps, Dr. C. A. Malott, Dr. E. R. Cumings, Dr. W. N. Logan, Dr. W. M. Tucker, Dr. S. S. Visher, Dr. P. B. Stockdale, and Dr. R. R. Shrock. Also many of the earlier reports of the Indiana Department of Geology and Natural Resources were freely consulted. Every effort will be made to credit published information to the proper authority. In many cases, however, it is not feasible to do this. The United States Geological Survey Water Supply Papers 21, 26 and 254 have been much used; Likewise the Handbook of Indiana Geology, 1922, has served as a mine of information. The appended bibliography contains a list of all references cited in the present report as well as additional publications that were consulted but which are not specifically cited in the text.

It is impossible to make individual mention of the many persons who have contributed information to this study. The writer, however, here wishes to express his appreciations for the many courtesies rendered. Several corporations, notably the Baltimore & Ohio Railroad Company, Smith-Monroe Company, Layne-Northern Company, the private water corporations in many towns and cities, the officials of many municipal water plants, and others have given information from their files and records. Members of the Indiana Well Drillers Association have given many data. The several summer field classes conducted under the guidance of Dr. W. N. Logan have gathered statistics and facts relating to ground water, also the several members of the Department of Geology faculty at Indiana University have contributed suggestions and information. Dr. C. A. Malott, in particular, I wish to mention, as he kindly supplied two of the plates accompanying the report and otherwise assisted in editing the manuscript. Dr. W. N. Logan instigated this study several years ago, kept it alive for a period of years, and then encouraged the writer to complete the final report. I am deeply indebted to Dr. Logan for his kindly attitude, beneficial cooperation and sustaining support. In particular am I grateful to Dr. Logan for his influence and position in securing the publication of this treatise.

PHYSIOGRAPHY

GENERAL FEATURES

The state of Indiana is situated within two physiographic provinces of the great Interior Plains, which extend from the Rocky Mountains eastward to the Appalachians. This classification by Fenneman (1) shows Indiana as a part of the Interior Low Plateau Province and a part of the Central Lowland Province. The unglaciated portion of southern Indiana is included in the Interior Low Plateau Province. The central two-thirds of Indiana is included in the Till Plains Section of the Central Lowland Province. The northern one-fourth of the State lies within the "Eastern Lake Section" of the Central Lowland Province.

(1) Fenneman, N. M., Physiographic Divisions of the United States: Annals of Association of American Geographers, Vol. VI, 1917, pp. 19-98, Plate I.

A complete study of the physiography of Indiana has been made by Malott, (2) who divided the State into natural units based on altitude, relief and related types of topographic forms. It has been deemed advisable in this report to follow Dr. Malott's subdivisions and Plate I shows these physiographic units.

(2) Malott, C. A., Physiography of Indiana, Part II, Handbook of Indiana Geology, Publication 21, Department of conservation, State of Indiana, 1922, pp. 61-256.

Approximately five-sixths of the surface area of the State of Indiana has been subjected to glaciation. The location of the State in the upper Mississippi basin plus the further fact that continental ice-sheets once covered the area explains in part the physiographic classification. The unglaciated area of Indiana is found in the central-southern one-third of the State. These two divisions of the State are useful in any study of the ground water and repeated reference will be made to them. In making a physiographic study of Indiana it is found that the border between the drift and the non-glaciated area does not stand out so conspicuously and that regional units extend from the driftless area for several miles into the glaciated region, especially where only one drift sheet is represented.

Dr. Malott's extensive studies of types of Indiana relief conditions and topographic forms permitted him to divide the State into nine distinct units. The older portion of Indiana, from a geologic and physiographic standpoint, is found in the southern part of the State. The difference in topographic condition in different parts of this older area gave rise to the various regional units which may readily be distinguished one from the other. The relative altitudes and the land forms exhibited by all but two of these units have resulted from the differential effects of erosion on the materials that immediately underlie the surface. Formations composed predominantly of sand or sandstone resist erosion more effectively than do formations composed of shale or clay. The area in which the sandy formations crop out therefore stand as hilly uplands, whereas the areas underlain by shale are reduced to gently undulating or moderately rolling plains between the hilly districts The two districts in which

the main features are not determined primarily by erosion are the Tipton Till Plain and the Northern Moraine and Lake Region. These are constructional plains which have not yet been strongly modified by destructive processes. The relation of these regions to the occurrence and recovery of ground water is discussed in more detail later.

THE DEARBORN UPLAND

In southeastern Indiana, from central Wayne County southward, in the area underlaid by the Ordovician strata, is an area about 75 miles long and 25 miles in width which is variable in relief. The area is an upland in which the relief ranges from 200 to 500 feet. This same physiographic district extends into Ohio and Kentucky, and is called the Dearborn Upland by Dr. Malott from its typical development in Dearborn Co. Indiana.

The Whitewater River basin, the Laughery River and many other small streams drain this area directly into the Ohio River. The Ohio River has an elevation of about 425 feet above sea level and the highest point on the Dearborn Upland is approximately 1100 feet above sea level. The proximity of the area to the Ohio River toward which the streams are cutting as a base explains their steep gradients and deep intrenchment.

The Dearborn Upland in Indiana, together with its eastern extension into Ohio, forms the catchment area of the ground waters found in the outcropping Upper Ordoviciam formations. The glacial drift covering the area varies in thickness and on some of the upland areas is quite thin. In certain localities the glacial mantle will supply ground water. The entire outcrop belt of Ordovician strata will not furnish good wells owing to the physical constitution of the rocks. The strata are made up of impermeable shales and dense limestones. Also due to the fact that many streams have cut deep valleys into the strata, the contained waters escape by seepage and by springs. A few perennial springs occur in the valleys where the water table has not been drained. The Ohio River, the Ohio River flood plain and the glacial drift are the chief sources of ground water in the Dearborn Upland region.

THE MUSCATATUCK REGIONAL SLOPE

The Muscatatuck Regional Slope corresponds in geographic extent to the outcrop of the Silurian formations and the Devonian limestone formations. This unit extends as far north as Rush and Shelby counties. Dr.C.A.Malott described and names this regional unit of physiography. In a distance of 25 miles there is a descent in elevation of approximately 225 feet from east to west. The divide between the drainage of the Dearborn Upland and the Muscatatuck Regional Slope which is drained by White River and the Muscatatuck River is the boundary between the two units. On the north this area is

covered with Wisconsin drift, though the drift is thin. In many places ground water occurs in this drift. The southern three-fourths of the Regional Slope area were mantled with Illinois drift, though much of the drift has been removed. This southern area is much dissected, with many streams deeply intrenched.

The bedrock of the Muscatatuck Regional Slope is chiefly limestone. Ground water occurs in the joint planes and crevices. The contact between glacial drift and bedrock is usually a good aquifer, provided stream valleys are not intrenched below this horizon, thus resulting in drainage and seepage.

THE SCOTTSBURG LOWLAND

The Scotsburg Lowland extends westward from the Muscatatuck Regional Slope to the Knobstone Escarpment. The western border of the Illinoian drift sheet is approximately the wesatern border of the Scottsburg Lowland, with the exception of a small area in Clark County and also an area north of the driftless area, in Bartholomew County. The Scottsburg Lowland coincides in its geographic distribution with the outcrop of the Devonian black shale, however, in the eastern half of Jackson County, due to the low areas along the White and Muscatatuck Rivers, the Scottsburg Lowland area swings westward and is in part underlain by strata of Mississippian age.

South of a line across northern Bartholomew County is found the Illinoian drift occurring over the Scottsburg Lowland areas. This drift, although variable in thickness, is a scource of ground water in many localities. The contact between the drift and the bedrock formation is also waterbearing, especially where the drift is of considerable thickness. The Devonian (New Albany) black shale is not an aquifer and wells drilled into the shale cannot be expected to supply ground water. Wells drilled through the shales into the underlying formation usually secure water, though in varing quantities. In the area underlain by Mississippian (Borden) strata, ground water cannot be expected. In the alluvial flats along the White and Muscatatuck rivers, local supplies of water may be secured.

THE NORMAN UPLAND

The Norman Upland coincides in its geographic distribution with the outcrop of the Mississippian (Borden group) strata belonging to the Osage series. A small exception has already been made where the Scottsburg Lowland unit shifts to the westward where the White and Muscatatuck rivers cut through the Knobstone Escarpment. The eastern boundary of the Norman Upland is the Knobstone Escarpment which extends from southern Johnson County southward to the Ohio River. The Knobstone Escarpment has been described as the greatest relief feature in Indiana. The western

border of the Norman Upland is the approximate junction between the clastic Borden strata and the superjacent Harrodsburg limestone.

The Borden group ranges in thickness from about 400 feet at the south end of the Indiana outcrop area to about 765 feet in central Brown County. Wells drilled into the Borden strata, which outcrop in a belt from 10 to 36 miles in width, do not secure sufficient quantities of water for domestic purposes and many of the wells secure brackish or salt water. The Borden rocks have long been known as poor producers of ground water, and this Norman Upland area has always been deficient in this respect.

In extreme northern Brown and Monroe counties the southmost limit of the Illinoian glacial drift is found. North of this line water can be secured in the drift, though even the drift is thin. The Wisconsin glacial drift covered the northern and eastern thirds of Morgan County and this area usually secures good water from the drift.

THE MITCHELL PLAIN

The Mitchell Plain corresponds in geographic extent to the outcrop of the Mississippian limestone known as the Harrodsburg, Salem, St. Louis and St. Genevieve formations. The name was given by Dr. J. W. Beede from its excellent development near Mitchell, Indiana. The surface is characterized by the formation of karst topography. The Mitchell Plain extends from Putnam County southeastward to the Ohio River. The eastern boundary of the Mitchell Plain is difficult to detect in the field but in general is located at the approximate contact between the distinctly limestone formations and the clastics of the Chester Series. This particular contact belt also shows a change from the limestone plain to the higher upland topography of the adjacent Crawford Upland unit.

The Mitchell Plain from the standpoint of ground water is very interesting. Underground drainage in the limestone area has been developed to a high degree. Wells find ground water at several horizons in the Mississippian limestones and springs are frequent in the area. Owing to the underground conduits and lack of information on these subterranean passageways, ground water may occur in rather restricted areas. It is conceivable that a given well could penetrate the entire limestone thickness and not encounter a joint plane or crevice and consequently be dry. Usually some water occurs at the formational contacts and a given well has a fair chance of securing some water, even though perhaps inadequate for domestic purposes.

THE CRAWFORD UPLAND

The Crawford Upland, the second largest of the southern Indiana regional units, corresponds in an approximate fashion to the geographic extent of the outcrop belt of the Mississippian (Chester) formations and the basal Pennsylvanian formations. The outcrop of these formations was not necessarily the basis for subdivision, though the geology is in large part responsible for the topographic expression. The eastern border of the Crawford Upland is the limestone bedrock Mitchell Plain and the western boundary is difficult to determine. Dr Malott has rather arbitrarily chosen this western border as a belt of decreasing relief associated with the inception of aggraded valleys. The Crawford Upland has the distinction of having within its borders certain of the roughest counties of the state. The diversity of the rocks and the proximity to the Ohio River of the southern portion of the Crawford Upland explain its ruggedness. Dr. Mallot describes the topographic condition of the area as follows:

> "Throughout the whole extent of the Crawford Upland the variety of topographic form and diversity of relief is bewildering. High hills, low hills; great ridges, some sharp, some rounded, and others flat-topped, but none of even altitude for any great distance; trench-like valleys, flat-bottomed valleys with wall-like bluffs, especially at the western margin; rock benches and structural plains of greater or less extent; remnants of an uplifted peneplain of rolling character left here and there amidst the extreme of differential dissection of the present erosion cycle, sinkholes, and swallow-holes, some of which are deeply sunk in loose sandstones, and due to underlying limestone high above the local water table; monadnocks, outliers, local cuestas escarpments, waterfalls, canyon-like gorges, natural bridges, caves, etc., all contribute their quota to the makeup of Indiana's most inaccessible area."

Another distinction of the Crawford Upland area is the fact that natural springs, both large and small are numerous. Several geologic horizons within the Chester Series which outcrop in this regional unit have excellent springs. Also the proper conditions for the occurence of natural springs are frequent.

THE WABASH LOWLAND

The Wabash Lowland of southwestern Indiana extends from near the center of Parke County southeastward to the western border of Perry County and includes all the territory west of this line to the Wabash River. It is the largest physiographic unit in southern Indiana. The entire area has

Pennsylvanian bedrock which is covered with Illinoian drift from Parke County south to a line extending from southeastern Daviess County to central western Posey County, which line is the boundary between the unglaciated and glaciated areas. South of the Illinoian glacial boundary the Wabash Lowland extends to the Ohio River. The aggraded valleys, the low altitude and low local relief are characteristics of the area.

In the glaciated area of the Wabash Lowland ground water is found in the drift in most areas, though the drift is thin in many places and is not an aquifer. Old lacustrine areas along the margins of the drift in Dubois, Gibson and Vanderburg counties usually afford supplies of sand which contain water. The Pennsylvanian formations as a whole bear ground water in fair quantities, though certain shale strata are impervious.

THE TIPTON TILL PLAIN

The southern part of northern Indiana which is bounded on the north by a line extending from Ft. Wayne to Kentland, partly by way of the Wabash River and on the south by the northern termination of the seven previously described physiographic units, approximately on a line extending from Richmond to Franklin and from Franklin to Rockville, is the large area known as the Tipton Till Plain. It is one of the constructional plains and as such is relatively unmodified. The surface is made up of ground moraine, terminal moraines and associated glacial features such as lakes, kames and eskers. Certain features of the region have been produced by the regular agencies of erosion since glacial formation of the plain.

Glaciation is responsible for the present surface configuration of the Tipton Till Plain, with definite local features to be explained by post-glacial weathering and erosion. The glacial drift varies from a few feet to as much as 500 feet in thickness. In most places ground water can be secured in the drift or at the contact between the drift and the bedrock. Specific zones within the drift which appear and lense out contain gravels and sand thus making better aquifers than the clayey till. Ordinary till will supply water, though slowly and ofttimes the supply is inadequate. The areas of outwash plain are composed of gravels and are excellent aquifers. A continental glacier does not possess the power to sort its load as does running water, therefore, our glacial drift contains heterogeneous materials.

The water-bearing beds in the rocks of the quaternary system are numerous and their positions are extremely variable. Nevertheless, many localities have what the drillers recognize as the various water beds, which will be discussed at greater length later when the waters of glacial deposits are discussed.

Many private wells and many public supplies obtain water in the Tipton Till Plain area from the glacial drift, but it is necessary in certain localities within this region to penetrate the bedrock fromations to secure adequate supplies.

NORTHERN MORAINE AND LAKE SECTION

The glaciated area of Indiana north of the Wabash River has been styled the Northern Moraine and Lake Section. The name is self-explanatory. Dr. C. A. Malott describes the area as a compound of massive rugged moraines occupied by lakes and broad lacustrine plaines. It is composed of the younger drift of the Wisconsin drift sheet. Post-glacial modification has been insignificant. This latter fact is attested by the presence of numerous lakes, swamps, peat bogs and moraines which resemble present mountain glacier moraines in their freshness. The moraines and lacustrine plains are made the basis for further subdivision of the region. The three divisions based on the presence of old lake sediments are the Calumet Lacustrine Section, the Kankakee Lacustrine Section and the Maumee Lacustrine Section. The two divisions characterized by the presence of irregular morainic masses are the Valparaiso Moraine Section and the Steuben Morainal Lake Section.

This Physiographic unit is also a constructional plain which is even less modified than the Tipton Till Plain. Geologic age and geographic location are the two factors which explain the present surface expression of the glacial debris.

The glacial drift in northern Indiana ranges from a few feet in parts of Pulaski, White and Newton counties to an extreme of 485 feet in Noble County. A well at Kendallville is reported to have passed through 485 feet of drift before penetrating bedrock.

The deposits of clay, sand, gravel, and boulders in the typical morainal belts, modified by fluvio-glacial action in localized areas, and also the deposits of finer sediments in the more typical lacustrine locations contain an abundance of ground water. For ordinary domestic supplies, wells drilled into the drift are sufficient to meet all needs, though cities and towns must frequently go deeper to secure adequate supplies. Within the last few months the city of Ft. Wayne has constructed two dams across the St. Joseph River valley to impound a water supply and will abandon entirely the many wells which have in the past supplied the city with water. An increasing population with consequent heavier demands for water supply and a gradual decline in the ground water source made it imperative that Ft. Wayne change to the present system of river supply.

In the Northern Moraine and Lake Region, it is possible to secure unusually abundant supplies of water from the drift, yet most of the larger wells are continued to the bedrock. The contact of the bedrock with the drift is an excellent aquifer, and in the southern part of the area the bedrock is limestone so fissured that it is capable of storing extraordinary quantities of the water which seeps down from above. From a study of well records it is believed that the two northern tiers of counties in the State are underlain by shales and siltstones of Devonian and Mississippian age. These formations are not aquifers They are remarkable for their inporosity and inability to give up the little water contained in the pores. Water in this region must come from the glacial drift, as deeper wells usually secure mineralized water.

CLIMATE

HISTORY OF WEATHER OBSERVATION DEVELOPMENT

The first series of meteorological observations organized under national control was inaugurated by the medical department of the army in 1819. Climatic observation within the present boundaries of Indiana were officially taken by medical officers of the United State military posts. By an order of the Surgeon-General, dated July, 1818, it became the duty of each hospital surgeon "to keep a diary of the weather" and these "diaries" have been continued at many army medical posts ever since, although the records have since 1890 been turned over to the Weather Bureau. Ward (3) tells us that "Meteorological"Registers" embodying the results of these observations were issued at various times, and in 1860 the Surgeon-General published a report which brought the results down to date, thus covering about forty years.

(3) Ward, R. DeC., The Climates of the United States, pp. 4-5, 1925.

In 1849 th Smithsonian Institution inuagurated a fairly extended system of weather observations. This was continued until 1874, when the meteorological work of the Institution was formally transferred to the War Department.

The actual establishment of a general national weather service came in 1870, in a joint resolution of Congress (approved Feb. 9, 1870), providing for the taking of meteorological observations at military posts and at other points and for giving notice of the approach and force of storms.

This important service was put in charge of the Chief Signal Officer of the army, and there remained until July 1, 1890, when it was transferred to the Weather Bureau of the Department of Agriculture.

Available records of the U. S. Weather Bureau give climatological data from many Indiana towns at an early date. A few are listed as follows: Laporte 1849, Logansport 1854, Rockville 1860, Indianapolis 1861, South Bend 1862, Muncie 1863, Vevay 1865, Laconia in Harrison County 1866, Bloomington and Knightstown 1868, Fort Wayne 1870, Evansville 1877. This list is not intended to be complete but reveals the fact that many of our known averages are based on many years of records.

At the present time 86 towns and cities in Indiana are given on the Weather Bureau tables as reporting on weather conditions.

GENERAL FEATURES

The climatic conditions of the State of Indiana are, on the whole, favorable to a good and constant supply of underground water. The most important of these conditions are precipitation and temperature, both of which are subject to marked variations from the normal. The fact that Indiana is located between latitudes 38 degrees and 42 degrees north and is also in the interior of a great continent gives the State a climate which is continental in character. The Gulf of Mexico furnishes moisture for the interior of the continent, and Indiana is located in the eastern portion of the great interior region which has high humidity and considerable rainfall. This same location is supplied with strongly marked seasons, with hot summers and cold winters. Dr. Visher(4)

(4)Visher, S. S., The Geography of Indiana, Part I, Handbook of Indiana geology, Publication 21, Dept. of Conservation, State of Indiana, 1922, pp. 1-58.

has pointed out that Indiana's climate closely resembles neighboring areas with strongly marked seasons, hot summers and cold winters; frequent changes of weather, due to the passage eastward of numerous cyclonic storms; high humidity and considerable rainfall; moderate cloudiness and windiness. These characheristics are in response to Indiana'a position in mid-latitudes (the belt of westerly winds, of cyclonic storms and of highly variable temperatures), in the interior of a great continent but not shut off from a source of moisture, the Gulf of Mexico

Indiana's location in mid-latitudes gives the State a touch of the extremes of climate. It is near the southern

STATIONS	Length of Record YEARS
Albion	14
Angola	33
Berne	21
Bluffton	35
Collegeville	30
Columbia City	..
Delphi	46
Fort Wayne	33
Fowler	..
Goshen	17
Hamlet	..
Hobart	12
Howe	25
Huntington	37
Kokomo	38
Lafayette	51
Laporte	34
Logansport	..
Marion	45
Monticello	..
Notre Dame	19
Plymouth	26
Rochester	18
Royal Center	13
South Bend	37
Thayer	..
Valparaiso	31
Wabash	6
Wheatfield	14
Whiting	21
Winamac	21
Winona Lake	23
Div. Average	44

STATIONS	Length of Record YEARS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Albion	14	22.8	28.0	37.9	47.7	58.2	67.9	72.3	70.0	64.4	52.1	39.6	27.9	49.1
Angola	33	24.0	24.8	34.9	47.6	59.5	69.0	73.1	70.7	64.5	51.9	38.7	28.6	48.9
Berne	21	25.7	28.6	38.6	49.6	60.1	69.3	74.2	72.1	65.9	51.0	40.6	29.6	50.4
Bluffton	35	26.1	27.1	38.8	49.9	60.6	69.2	74.3	72.0	65.7	53.7	40.5	29.1	50.6
Collegeville	30	25.0	27.3	39.5	49.3	61.0	69.7	74.4	72.3	65.6	54.2	41.2	28.7	50.7
Columbia City	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Delphi	46	25.3	27.6	38.7	50.4	61.2	70.7	74.8	72.3	65.7	53.0	40.2	29.7	50.8
Fort Wayne	33	26.1	26.8	39.1	49.0	60.1	69.5	73.7	71.2	65.1	53.6	40.8	28.7	50.1
Fowler	..	26.0	28.0	39.8	50.5	61.4	70.3	74.6	72.7	65.8	54.5	41.8	29.3	51.2
Goshen	17	22.8	27.8	37.4	48.1	57.5	67.4	72.6	71.0	64.0	52.5	39.8	27.4	49.0
Hamlet	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Hobart	12	23.2	29.4	38.2	48.0	58.8	68.9	73.8	71.5	66.2	53.8	39.9	27.9	50.0
Howe	25	23.7	25.5	35.8	46.6	57.9	67.9	73.1	70.5	64.1	51.7	39.0	27.5	48.6
Huntington	37	25.8	26.8	38.7	49.3	60.6	69.5	74.3	72.3	66.3	53.4	40.6	29.3	50.6
Kokomo	38	27.0	38.3	40.4	51.4	62.3	71.2	75.6	73.1	66.9	54.8	41.9	30.5	52.0
Lafayette	51	25.7	28.0	38.9	50.8	61.6	70.8	75.0	72.9	66.4	54.1	40.7	29.9	51.2
Laporte	34	23.3	24.8	36.5	47.2	58.4	67.9	73.3	71.0	64.1	52.6	39.5	26.9	48.8
Logansport	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Marion	45	26.7	28.1	39.3	50.7	60.9	70.1	74.2	72.2	66.0	53.7	41.2	30.2	51.1
Monticello	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Notre Dame	19	24.6	27.5	37.3	48.2	58.7	68.1	73.4	70.9	64.4	53.6	41.0	28.8	49.7
Plymouth	26	24.3	26.6	36.9	48.2	58.0	67.3	72.5	70.7	64.4	52.4	39.8	28.0	49.1
Rochester	18	25.8	26.9	37.7	49.1	60.3	69.0	74.2	71.9	65.4	51.9	40.3	28.5	50.1
Royal Center	13	23.7	29.7	38.2	48.5	58.6	68.3	72.5	70.3	64.4	53.4	39.7	28.7	49.7
South Bend	37	24.3	24.7	36.6	48.2	59.6	68.5	73.3	71.4	65.2	53.3	40.0	27.8	49.4
Thayer	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Valparaiso	31	23.5	25.1	36.4	48.2	58.0	68.0	72.4	71.0	65.0	53.3	39.4	27.6	49.0
Wabash	6	25.7	26.8	38.6	49.8	60.5	69.7	74.6	72.5	66.2	53.5	41.2	29.2	50.7
Wheatfield	14	23.2	28.8	38.8	48.5	58.7	69.2	73.4	71.2	65.0	53.2	37.6	28.3	49.7
Whiting	21	24.1	28.0	38.1	48.5	58.7	68.3	74.2	72.4	66.1	54.8	41.7	28.4	50.3
Winamac	21	25.7	28.[illegible]	39.6	49.5	60.8	69.3	74.0	71.1	65.4	54.1	40.6	28.2	50.6
Winona Lake	23	24.8	27.6	37.7	49.3	59.8	69.1	73.9	71.7	65.6	53.7	41.0	28.8	50.2
Div. Average	44	25.0	27.1	37.7	49.2	59.9	69.5	73.8	71.5	65.2	52.8	40.0	29.2	50.1

STATIONS	Length of Record
Anderson	36
Bloomington	35
Cambridge City	39
Covington	..
Crawfordsville	29
Farmersburg	32
Farmland	48
Frankfort	17
Greencastle	26
Greenfield	27
Hickory Hill	18
Indianapolis	46
Martinsville	..
Mauzy	50
Muncie	..
Noblesville	..
Richmond	43
Rockville	44
Salamonia	25
Shelbyville	27
Terre Haute	38
Veedersburg	31
Whitestown	35
Div. Average	44

STATIONS	Length of Record YEARS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Bedford	22	31.6	33.2	44.2	54.1	63.9	73.5	77.1	75.5	68.9	57.3	45.1	35.0	54.9
Boonville	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Brookville	6	29.1	29.5	40.4	51.0	61.2	69.3	74.1	72.0	66.1	54.0	41.2	31.2	51.6
Butlerville	45	30.8	32.5	43.2	53.7	63.5	72.0	76.1	74.4	68.7	56.0	43.9	33.9	54.1
Columbus	47	29.3	31.1	41.7	52.7	62.7	71.7	75.8	73.8	67.4	55.0	43.0	32.8	53.1
Decker	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Edwardsport	2	30.3	32.5	44.0	54.4	64.4	73.1	77.2	75.6	69.8	57.8	44.2	33.5	54.8
Elliston	49	29.5	32.1	43.1	53.9	63.4	72.2	75.9	74.1	68.0	55.9	43.5	33.2	53.7
Evans Landing	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Evansville	46	33.5	36.3	45.9	56.7	66.7	75.1	78.9	77.4	70.7	59.4	46.6	37.1	57.0
Forest Reserve	18	32.8	35.7	44.6	54.9	63.3	72.0	76.5	75.0	68.9	57.9	46.1	35.4	55.2
Greensburg	34	28.5	29.6	41.8	52.1	61.5	70.8	75.4	73.5	67.8	55.6	43.0	31.4	52.6
Huntingburg	24	34.4	36.8	45.5	55.7	64.6	73.4	77.3	76.1	70.8	57.5	46.1	36.3	56.2
Jeffersonville	44	34.1	35.8	45.7	56.1	65.9	74.5	78.2	76.2	69.8	57.5	45.8	36.8	56.4
Leavenworth	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Madison	37	33.2	34.4	45.6	55.6	65.6	73.6	77.6	76.3	70.6	58.1	44.9	35.6	55.9
Marengo	48	32.0	34.8	44.5	54.8	63.9	72.5	75.9	74.3	68.6	56.3	44.7	34.9	54.8
Moores Hill	29	30.4	31.9	43.2	52.6	62.5	70.8	75.2	73.9	68.1	56.2	44.0	32.6	53.4
Mount Vernon	44	33.2	34.8	45.2	56.0	65.7	74.7	78.4	77.0	70.5	57.8	45.8	36.0	56.3
Paoli	33	31.8	33.1	44.5	53.9	63.7	71.9	76.2	74.7	68.7	56.8	44.8	34.0	54.5
Princeton	48	31.8	34.0	44.6	55.3	65.0	74.1	77.7	75.9	69.7	57.2	45.0	35.5	55.5
Rome	28	35.5	37.2	47.6	56.7	66.2	74.3	78.2	77.2	72.0	59.3	47.3	37.5	57.4
Salem	36	31.6	33.1	44.0	53.5	63.3	71.5	76.1	74.5	68.3	55.9	44.3	33.8	54.2
Scottsburg	37	32.7	33.9	44.9	54.9	64.9	73.5	77.4	75.7	69.7	57.0	45.0	34.9	55.4
Seymour	42	31.6	33.3	43.5	54.3	63.7	72.6	76.4	74.6	68.4	56.4	44.2	34.7	54.5
Shoals	18	30.4	34.0	43.3	54.1	62.8	71.7	75.8	73.7	67.4	55.5	43.7	33.7	53.8
Stewartsville	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Vevay	49	32.7	34.6	42.9	53.9	64.6	73.7	77.0	75.3	69.5	57.4	45.5	36.2	55.3
Vincennes	37	31.2	32.7	44.5	55.4	65.9	74.4	78.5	76.9	70.8	58.0	44.9	34.1	55.6
Washington	35	31.5	33.2	45.0	54.5	64.6	73.1	77.4	76.1	70.2	58.0	45.6	34.0	55.3
Williams	44	....	....	....	....	....	....	....	....	....	....	....	....	....
Div. Average	44	31.9	33.4	43.7	54.6	64.3	73.3	76.8	75.1	69.1	56.5	44.4	35.2	54.8
State Average	44	28.4	30.2	40.7	51.9	62.1	71.2	75.3	73.2	67.0	54.6	42.2	32.1	52.4

STATIONS	Length of Reach
Anderson	36
Bloomington	35
Cambridge City	39
Covington	..
Crawfordsville	29
Farmersburg	32
Farmland	48
Frankfort	17
Greencastle	26
Greenfield	27
Hickory Hill	18
Indianapolis	46
Martinsville	..
Mauzy	50
Muncie	..
Noblesville	..
Richmond	43
Rockville	44
Salamonia	25
Shelbyville	27
Terre Haute	38
Veedersburg	31
Whitestown	35
Div. Average	44

CENTRAL DIVISION

STATIONS	Length of Record YEARS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Anderson	36	28.0	29.3	40.8	51.1	61.4	70.2	74.3	72.5	66.6	56.5	43.8	31.6	52.2
Bloomington	35	29.8	31.2	42.8	52.2	63.4	71.8	76.2	74.5	68.2	56.4	43.7	32.6	53.6
Cambridge City	39	27.3	28.3	40.0	50.2	60.3	69.1	73.5	71.5	65.3	53.0	40.7	30.4	50.8
Covington	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Crawfordsville	29	27.6	29.7	41.2	52.0	63.1	71.9	75.6	73.9	67.8	55.5	42.7	30.9	52.7
Farmersburg	32	29.8	31.7	43.0	52.6	63.3	71.1	76.0	74.3	68.3	56.3	44.0	31.6	53.5
Farmland	48	27.1	29.0	39.2	50.2	60.8	69.8	73.7	71.4	65.4	53.3	41.1	31.4	51.0
Frankfort	17	26.8	31.5	40.5	51.2	61.1	70.3	74.5	72.2	66.1	55.1	42.5	30.2	51.8
Greencastle	26	27.6	30.1	41.4	52.0	62.8	71.2	76.0	74.1	67.8	56.0	42.7	31.1	52.7
Greenfield	27	28.5	30.8	41.7	51.9	61.6	70.6	75.0	72.9	67.4	55.1	43.0	31.6	52.5
Hickory Hill	18	30.6	34.3	43.2	54.2	63.6	71.9	76.3	74.1	68.3	57.5	45.3	33.7	54.4
Indianapolis	46	28.4	31.1	40.0	52.1	62.9	71.6	75.7	73.7	66.9	55.7	42.3	32.2	52.7
Martinsville	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Mauzy	50	26.8	28.9	38.9	50.2	60.7	69.7	73.5	71.1	65.4	53.0	40.5	30.3	50.8
Muncie	..	....	....	....	....	....	....	....	....	....	....	....	....	....
Noblesville	...	....	....	....	....	....	....	....	....	....	....	....	....	....
Richmond	43	27.0	28.9	38.9	49.9	60.2	68.8	73.2	70.6	64.8	52.7	40.6	30.5	50.5
Rockville	44	28.1	30.1	40.7	52.2	62.2	71.2	75.4	73.5	67.4	55.1	42.4	31.4	52.5
Salamonia	25	26.5	29.2	39.5	49.6	59.6	68.4	73.0	71.0	65.6	53.2	41.3	30.0	50.6
Shelbyville	27	28.8	31.2	41.9	51.9	62.2	71.5	75.2	73.4	67.7	55.2	42.6	31.8	52.8
Terre Haute	38	30.0	31.4	43.2	53.8	64.4	72.9	77.3	75.4	69.2	57.2	44.2	33.0	54.3
Veedersburg	31	27.5	29.9	42.3	52.3	62.7	71.0	75.3	73.9	67.9	56.1	42.8	31.1	52.7
Whitestown	35	26.6	27.9	39.5	50.1	61.2	69.8	74.3	72.1	65.6	53.6	40.9	29.5	50.9
Div. Average	44	28.2	30.0	40.6	51.8	62.2	71.2	74.9	72.9	66.8	54.6	42.2	31.9	52.2

margin of the area having long and cold winters. The normal January temperature for the State is about 28 degrees Fahrenheit. Indiana also is located on the northern margin of the belt which has long and hot summers. The average July temperature for the entire State is 75 degrees Fahrenheit. The mean maximum daily temperatures for June, July ans August are more than 80 degrees Fahrenheit, for most of the Weather Bureau stations in Indiana. Occasionally extreme summer temperatures are experienced which make a season with high average temperatures a bit trying. The high relative humidity in sumer gives an impression of high sensible temperatures. This same factor operates in winter to make cold weather more disagreeable. The average normal temperature for December, January and February for the entire State is 30 degrees Fahrenheit. Temperatures as low as 33 degrees below at LaFayette and 30 degrees below at Marengo have been recorded. These extremely low temperatures are rare and of short duration.

The average amount of precipitiation received annually in Indiana is about 40 inches. Snowfall makes up about one-tenth of the total precipitation in the northern part of the State and about one-twentieth in the southern part.

Indiana, having a mean latitude of 40 degrees, has a relatively typical continental climate, although its inland location, westerly winds and frequent cyclonic storms lend rigors to both summer and winter. The succession of cyclonic storms gives frequent and sudden changes in weather. In general, the climate ranges from temperate to the extremes of seasonal possibilities. The rainfall is abundant for the needs of agriculture. The relative humidity averages about 70 per cent for the entire State. The growing season for the whole State averages about 170 days. Indiana has more sunshine than areas to the east or north. Records show that the State has about one-third of all the days of the year clear, one-third cloudy and the remainder partly cloudy.

TEMPERATURE

The mean annual temperature of Indiana is 52.4 degrees Fahrenheit. This figure is based on records which have been taken at various points in the State for a period of 44 years, so that much variation from this figure could not be expected. Owing to Indiana's location in the interior of the continent and within the sweep of winter cold waves from the west and northwest, and the occasional heated spells common to the Mississippi Valley, the average annual range of temperature is much greater. Definite figures are not available for the average annual range of temparature, but the highest temperature , 112 degrees recorded in the State was at Salem on July 22, 1901. The lowest official temperature recorded was 33 degrees below zero at LaFayette on January 2, 1887, thus making an extreme range of 145 degrees.

The mean annaual temperature decreases gradually from the southern part of Indiana on the Ohio River to the northern and higher portions of the State. Records of the U. S. Weather Bureau show that Howe, in Lagrange County, has an average annual temperature of 48.6 degrees and that Rome, in Perry County, has an average annual temperature of 57.4 degrees. Howe is located within a short distance of the Michagan State line and Rome is in extreme southern Indiana on the Ohio River.

The annual range between average monthly mean maximum and average monthly mean minimum temperature is about 46.9 degrees. It ranges from 28.4 degrees in January to 75.3 degrees in July. These figures are from the average means for the State.

The last killing frost in the spring occurs about April 15th in southwestern Indiana and about May 1st in northeastern Indiana. These are average dates as given by the U. S. Weather Bureau. Usually the first killing frost in the fall occurs about October 5th in the northern part of the State and October 20th in the southwestern corner of the State. Visher (5) has

(5) Ibid., p. 19.

pointed out that latitude is the chief factor affecting the length of the growing season; and that on the average the season decreases in length toward the north. Other factors bearing on this are altitude, storminess and nearness to Lake Michigan.

In northern Indiana the ground is frozen for about four months each year and during this period little precipitation can penetrat the ground. It might be added that the precipitation is chiefly in the form of snow. Similar conditions prevail in the southern part of the State, with a shorter period of frozen ground and about one-half the snowfall. During the remaining eight months the soil is in condition to absorb large amounts of rainfall, which in turn replenishes the groung water supply. Southern Indiana is peculiarly situated with respect to certain factors which determine the relations between precipitation, temperature and ground water. A largeer percentage of the rainfall received comes in spring and summer. The higher average temperature in the southern half of the State causes greater evaporation to take place. Also southern Indiana is quite hilly and precipitation escapes more readily. Another factor is that southern Indiana receives more rains of the quick-falling storm variety, with little chance for absorption into the hilly soils.

Simpson(6) has discussed the relations of temperature

(6) Simpson, H. E. Ground-Water Resources of North Dakota, U. S. Geological Survey, Water-Supply Paper 598, 1929, p. 13.

to ground water as follows:

"The relations of temperature to ground water are very complex. They include the immediate and direct relations that govern the amount, rate, and from of the precipitation; those that determine the proportionate parts of the rain and snow that evaporate, run off, or absorbed, as affected by the evaporativity of the atmosphere and by the freezing, baking, etc., of the surface; and those that govern the movements of ground water. The last item is commonly overlooked but its importance may be suggest

ed by the fact that water at 100 degrees F. has a viscosity only a little more than half that of water at 50 degrees F. and hence percolates nearly twice as rapidly through sand of a given texture as water at 50 degrees; both absorption and flow therefore vary greatly with the temperature."

The following tables show the normal annual temperature for Indiana. They are based on all available data to and including 1930, except that normals for stations with less than 11 years' record were interpolated. Division and State normanl were not derived by averaging the station data shown, but include data for stations discontinued previously to 1930. These tables were prepared and distributed by the U. S. Weather Bureau.

STATIONS	Length of Record YEARS
Albion	14
Argola	33
Berne	21
Bluffton	35
Collegeville	35
Columbia City	29
Delphi	46
Fort Wayne	50
Fowler	3
Goshen	17
Hamlet	5
Hobart	12
Howe	25
Huntington	43
Kokomo	40
Lafayette	52
Laporte	37
Logansport	52
Marion	44
Monticello	20
Notre Dame	19
Plymouth	27
Rochester	18
Royal Center	50
South Bend	43
Thayer	5
Valparaiso	32
Wabash	18
Wheatfield	14
Whiting	21
Winamac	25
Winona Lake	23
Division Average	44

STATIONS	Length of Record YEARS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Albion	14	1.80	1.18	2.66	3.16	3.13	3.58	2.47	2.63	3.27	2.88	2.47	2.47	31.70
Argola	33	2.45	2.33	3.18	3.11	3.80	3.82	3.58	3.20	3.49	2.82	3.23	2.70	37.71
Berne	21	2.75	1.50	3.53	3.55	3.84	3.53	3.79	3.41	3.52	2.89	2.61	2.64	37.56
Bluffton	35	2.73	1.95	3.78	3.41	3.91	3.90	3.94	3.49	3.07	2.68	2.69	2.76	38.31
Collegeville	35	2.17	1.89	3.23	3.60	4.82	3.74	4.12	3.55	3.53	2.71	2.71	2.28	38.35
Columbia City	29	2.41	1.97	3.34	3.36	4.16	3.52	3.57	3.04	3.87	2.28	3.03	2.36	36.91
Delphi	46	2.79	2.14	3.21	3.49	4.49	4.04	3.56	3.28	3.36	2.50	2.95	2.57	38.38
Fort Wayne	50	2.33	2.35	3.22	3.07	3.85	3.57	3.60	3.11	3.06	2.60	2.88	2.58	36.22
Fowler	3	2.60	1.90	2.80	3.40	4.70	3.80	3.70	3.40	3.40	2.80	2.60	2.50	37.60
Goshen	17	1.87	1.18	2.59	3.41	3.64	3.05	2.34	2.53	3.25	3.11	2.33	2.31	31.61
Hamlet	5	2.10	1.80	2.90	3.04	3.68	3.50	3.15	3.40	3.40	2.80	2.70	2.40	34.87
Hobart	12	1.80	1.32	3.13	3.22	3.05	3.36	3.10	2.82	3.77	3.08	2.83	2.13	33.61
Howe	25	2.23	1.80	2.78	3.52	4.07	3.81	3.30	2.90	3.13	3.14	2.86	2.53	36.07
Huntington	43	2.67	2.14	3.08	3.08	4.17	3.75	3.57	3.40	3.02	2.70	3.02	2.37	36.97
Kokomo	40	2.94	2.14	3.46	3.66	4.15	3.67	3.77	3.50	3.34	2.80	2.98	2.54	38.95
Lafayette	52	2.60	2.37	3.15	3.53	4.33	4.09	3.80	3.44	3.23	2.66	2.84	2.67	38.71
Laporte	37	2.27	2.24	3.11	3.06	4.11	3.78	3.21	3.50	3.33	3.13	2.95	2.55	37.24
Logansport	52	2.43	2.40	2.88	3.31	4.28	3.72	3.32	3.04	3.44	2.58	3.02	3.99	38.41
Marion	44	2.87	2.07	3.54	3.51	3.77	3.90	3.10	3.20	3.44	2.60	2.86	2.76	37.62
Monticello	20	2.67	1.78	2.77	3.30	3.98	3.39	3.38	3.60	3.32	2.94	2.22	2.43	35.78
Notre Dame	19	2.15	1.25	2.70	2.98	3.71	3.22	2.68	2.70	3.30	2.97	2.32	2.17	32.15
Plymouth	27	2.06	1.66	2.81	3.02	4.11	3.39	3.10	3.47	3.40	2.78	2.65	2.29	34.74
Rochester	18	2.58	1.95	2.55	3.34	4.04	3.78	3.52	3.79	3.42	2.12	2.94	2.61	36.64
Royal Center	50	2.29	2.36	2.94	3.07	4.06	3.53	3.79	2.56	2.88	2.98	2.67	2.69	35.82
South Bend	43	2.33	1.77	2.84	2.97	3.72	3.25	3.02	3.23	3.27	2.80	2.84	2.60	34.64
Thayer	5	2.02	1.50	2.80	3.65	4.50	3.70	3.98	3.30	3.50	2.90	2.60	2.30	36.75
Valparaiso	32	1.98	1.73	2.93	3.07	4.05	3.62	3.14	3.19	3.43	2.62	2.36	2.19	34.31
Wabash	18	2.30	2.60	3.04	3.35	4.31	4.28	3.69	3.30	3.21	3.07	2.90	3.66	39.71
Wheatfield	14	1.82	1.28	2.61	3.74	3.30	3.60	3.04	3.10	3.55	2.91	2.25	2.49	33.69
Whiting	21	1.90	1.39	2.67	3.01	3.73	3.38	2.84	3.32	3.02	2.91	2.33	2.01	32.51
Winamac	25	1.82	1.63	3.23	3.37	3.80	3.58	3.33	2.89	3.44	3.34	2.67	2.51	35.61
Winona Lake	23	2.58	1.96	2.93	3.61	4.00	3.44	3.25	3.45	3.28	2.87	2.74	2.42	36.53
Division Average	44	2.43	2.02	3.08	3.23	4.02	3.60	3.32	3.09	3.12	2.63	2.82	2.39	35.75

STATIONS	Length of Record YEARS
Bedford	22
Connville	3
Brookville	6
Butlerville	45
Columbus	47
Decker	17
Edwardsport	7
Elliston	48
Evans Landing	8
Evansville	50
Forest Reserve	19
Greensburg	35
Huntingburg	35
Jeffersonville	48
Leavenworth	5
Madison	37
Marengo	48
Moores Hill	29
Mount Vernon	44
Paoli	33
Princeton	48
Rome	28
Salem	40
Scottsburg	37
Seymour	42
Shoals	20
Stewartsville	4
Vevay	65
Vincennes	45
Washington	35
Williams	10
Div. Average	44
State Average	44

SOUTHERN DIVISION

STATIONS	Length of Record YEARS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Bedford	22	3.30	2.82	4.02	3.89	3.63	4.10	2.58	3.83	3.47	3.78	3.55	3.75	42.72
Boonville	3	3.75	3.25	4.15	3.92	3.80	4.05	3.30	3.30	3.28	2.80	3.50	3.50	42.60
Brookville	6	3.50	2.80	4.02	3.50	3.80	3.60	3.50	3.40	3.30	2.95	2.85	3.10	40.32
Butlerville	45	4.34	3.22	4.74	4.11	4.69	4.29	3.52	3.93	3.24	3.11	3.64	3.44	46.27
Columbus	47	3.48	2.77	3.79	3.59	3.46	3.65	2.85	3.69	3.38	2.80	3.11	2.99	39.56
Decker	17	3.64	2.22	3.59	3.29	4.10	4.46	2.08	3.67	3.07	3.57	2.50	3.79	39.98
Edwardsport	7	3.60	2.75	4.20	3.80	4.10	4.30	3.45	3.70	3.65	3.20	3.50	3.25	43.50
Elliston	48	3.27	2.94	4.07	3.61	4.19	4.19	3.34	3.46	3.26	2.92	3.33	3.22	41.80
Evans Landing	8	4.40	3.30	4.50	4.40	4.10	3.90	3.80	3.50	3.20	3.02	3.50	3.80	45.42
Evansville	50	3.74	3.24	4.19	3.90	3.86	4.04	3.42	3.36	3.31	2.82	3.74	3.54	43.16
Forest Reserve	19	4.46	2.37	4.09	3.96	3.97	3.99	3.48	4.04	3.39	3.03	3.07	3.37	43.72
Greensburg	35	3.30	2.81	4.20	3.45	3.75	3.63	3.79	3.28	3.38	3.10	2.79	3.01	40.49
Huntingburg	35	4.45	4.04	4.26	4.73	4.71	4.42	4.01	4.02	3.98	3.49	3.69	4.06	49.86
Jeffersonville	48	4.05	3.39	4.28	3.90	3.92	3.78	3.66	3.37	2.72	2.71	3.56	3.65	42.99
Leavenworth	5	4.60	4.00	4.90	4.60	4.50	4.50	4.00	3.70	3.50	3.25	3.90	4.10	49.55
Madison	37	4.10	2.86	4.32	3.86	4.32	4.23	3.55	3.49	3.19	3.07	3.17	3.57	43.73
Marengo	48	4.55	4.46	5.08	4.68	4.90	4.70	4.05	3.88	3.88	3.22	4.13	4.17	51.70
Moores Hill	29	3.79	2.74	4.03	3.84	4.19	3.52	3.25	3.66	3.22	3.06	2.86	3.16	41.32
Mount Vernon	44	3.81	2.82	4.34	3.98	3.81	3.83	3.44	3.22	3.21	3.01	3.46	3.42	42.35
Paoli	33	3.58	2.67	4.27	3.69	4.30	3.87	3.23	4.23	3.57	3.42	2.98	3.70	43.51
Princeton	48	3.66	2.98	4.22	3.63	3.78	4.09	3.09	3.27	3.43	2.68	3.25	3.48	41.56
Rome	28	4.86	3.24	4.46	4.55	4.23	4.09	3.94	3.51	3.25	3.38	3.49	4.03	47.03
Salem	40	4.10	3.20	4.19	3.70	4.06	3.79	3.13	3.66	3.17	3.13	3.54	3.74	43.41
Scottsburg	37	3.81	2.68	4.23	3.76	3.94	3.90	3.35	3.52	2.88	2.97	3.13	3.56	41.73
Seymour	42	3.62	3.12	4.23	3.73	4.07	4.02	3.19	3.62	3.31	3.12	3.16	3.31	42.50
Shoals	20	3.78	2.21	4.09	3.76	4.37	3.79	3.06	4.35	3.69	3.46	2.63	3.87	43.06
Stewartsville	4	3.05	2.90	4.25	3.90	3.79	3.95	3.40	3.25	3.28	2.98	3.40	3.40	41.55
Vevay	65	4.13	3.33	4.13	3.57	4.24	4.68	3.91	3.63	3.24	2.63	3.16	3.67	44.32
Vincennes	45	3.78	2.99	4.58	3.96	4.04	4.47	3.60	3.61	3.75	3.15	3.65	3.33	44.91
Washington	35	3.72	2.61	4.52	3.67	4.01	4.32	3.25	4.00	3.66	3.24	3.02	3.39	43.41
Williams	10	3.49	2.61	3.61	3.71	3.98	3.54	2.87	3.65	4.68	2.87	3.20	3.77	41.98
Div. Average	44	3.91	3.17	4.29	3.89	4.10	4.03	3.34	3.51	3.26	2.92	3.43	3.47	43.32
State Average	44	3.13	2.52	3.75	3.56	4.06	3.86	3.38	3.34	3.24	2.74	3.10	2.86	39.54

STATIONS	Length of Record
Anderson	36
Bloomington	47
Cambridge City	39
Covington	5
Crawfordsville	32
Farmersburg	32
Farmland	49
Frankfort	19
Greencastle	34
Greenfield	28
Hickory Hill	18
Indianapolis	58
Martinsville	8
Mauzy	58
Muncie	28
Noblesville	18
Richmond	68
Rockville	48
Salamonia	38
Shelbyville	38
Terre Haute	58
Veedersburg	3
Whitestown	3
Div. Average	4

STATIONS	Length of Record YEARS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Anderson	36	2.75	1.76	3.67	3.48	4.02	3.85	3.74	3.75	4.78	2.68	2.94	2.61	40.03
Bloomington	47	3.79	3.04	4.76	3.74	4.12	3.96	3.95	3.85	3.27	3.23	3.15	3.49	44.35
Cambridge City	39	3.22	1.96	4.30	3.92	3.79	4.38	3.59	3.41	3.52	2.85	2.94	2.95	40.83
Covington	5	2.66	1.85	3.20	3.40	4.00	3.90	3.68	3.45	3.40	2.90	2.40	2.50	37.34
Crawfordsville	32	2.73	1.83	4.04	3.47	3.95	3.62	3.45	3.87	3.93	2.88	2.74	2.52	39.03
Farmersburg	32	2.48	1.86	3.49	3.05	4.30	3.64	2.98	3.37	3.48	2.98	2.35	2.60	36.58
Farmland	49	2.77	2.38	3.59	3.55	3.90	4.09	3.48	3.72	3.51	2.40	2.78	2.60	38.77
Frankfort	19	2.75	2.19	3.60	3.29	4.89	4.35	4.20	3.49	3.90	3.57	2.60	2.81	41.64
Greencastle	34	2.71	2.02	4.37	3.84	4.30	4.91	3.53	4.22	3.81	3.00	2.94	3.38	43.03
Greenfield	28	2.82	2.25	3.86	3.73	3.98	3.96	3.84	4.04	3.37	2.56	2.99	2.31	39.71
Hickory Hill	18	3.58	1.87	3.91	3.63	4.05	3.68	2.96	3.88	3.97	3.09	3.09	3.11	40.82
Indianapolis	50	2.95	2.73	3.93	3.62	3.89	3.62	3.34	3.31	3.40	2.78	3.35	2.98	39.90
Martinsville	8	2.95	2.05	4.00	3.68	4.10	3.90	3.30	3.90	3.60	3.10	3.05	3.20	40.83
Mauzy	50	3.42	2.94	4.10	3.60	4.10	3.94	3.26	3.31	3.11	2.91	3.24	3.08	41.01
Muncie	22	2.75	2.48	4.23	4.24	4.13	4.12	3.54	4.18	4.05	2.49	3.42	3.00	42.62
Noblesville	17	2.95	1.63	3.53	4.04	4.05	4.45	3.87	3.31	4.24	2.70	2.84	2.91	40.52
Richmond	61	2.90	2.38	3.76	3.45	3.91	4.01	3.63	3.81	3.57	2.87	3.14	2.99	40.42
Rockville	46	2.78	2.14	3.74	3.68	4.03	3.92	3.44	3.34	3.44	2.88	3.17	2.76	39.32
Salamonia	33	3.30	2.26	4.18	4.02	3.60	3.88	3.77	3.32	3.26	2.55	2.68	2.85	39.67
Shelbyville	37	3.41	2.63	4.11	3.84	4.11	3.90	3.55	3.33	3.17	3.17	3.06	2.95	41.23
Terre Haute	50	2.70	2.63	3.76	3.66	3.87	3.93	3.18	3.25	3.62	2.73	3.31	2.93	39.57
Veedersburg	31	2.63	1.85	3.20	3.40	3.99	3.91	3.69	3.50	3.42	2.94	2.25	2.52	37.30
Whitestown	35	2.97	2.00	4.13	3.65	4.24	3.77	3.66	3.48	3.49	2.85	2.70	2.66	39.60
Div. Average	44	3.05	2.36	3.89	3.55	4.05	3.94	3.49	3.43	3.35	2.67	3.04	2.72	39.54

PRECIPITATION

The mean annual precipitation in Indiana ranges from approximately 35 inches in the north to slightly over 50 inches in the central-southern part of the State. United States Weather Bureau records show that Lake, Porter, northern Laporte, St. Joseph, northeastern Marshall, Elkhart, Noble, northern Kosciusko and western Lagrange counties receive less than 35 inches of precipitation. The region which receives more than 50 inches of precipitation includes Crawford and small portions of Orange, Washington, Harrison, Perry and Dubois counties. It is interesting to note that this small area in southern Indiana receives about 43 per cent more precipitation than the driest part of the State. By a stretch of imagination one may detect some accordance between rainfall and surface contour, the major stream valleys receiving the least rainfall and the higher portions of the State the most. Minor topographic features may exert a pronounced local influence, which perhaps explains the heavy concentration of rainfall in Crawford county. The county is topographically high with drainage in all directions. It is also located between two major stream valleys.

The U. S. Weather Bureau divides Indiana into three divisions namely, Northern, Central and Southern. The average precipitation for the Northern Division is 37.75 inches, The average for the Central Division is 39.54 inches, which incidentally is the average for the entire state. The average for the Southern Division is 43.32 inches.

The moisture that falls as rain or snow over Indiana comes chiefly from the gulf of Mexico and the Atlantic Ocean. The State is within the belt of cyclonic storms, ordinarily known as Lows or low pressure areas. Statistics show that the southern part of Indian is crossed by the centers of about twenty disturbances, or Lows per year. Northern Indiana has about thirty, which also explains the more sudden and varied changes of weather in this section. As the areas of low pressure move eastward across the continent with the prevailing westerly winds, the warm, moist air from the south and southeast is drawn into the eddies and causes southerly winds and mild temperatures. Because of the cooling of the air currents, condensation occurs with resultant precipitation. The cyclone moves eastward gradually, the winds become northwesterly, and cooler air ushers in lower temperatures and clear skies. The cyclones bring us our changes in weather. The tornado, which is localized in extent of violent nature and destructive in effect must not be confused with the cyclones or Lows. Tornadoes occur occasionally in Indiana. They usually do extensive damage to a limited area, though the destruction is dependent upon the intensity of the storm and the path over which it sweeps.

The following tables show the normal annual precipitation for Indiana. They are based on all available data to and including 1930, except that normals for stations with less than 11 years' record were interpolated. Division and State normals were not derived by averaging the station data shown, but include data for stations discontinued previously to 1930. These tables were prepared by the U. S. Weather Bureau.

SEASONAL DISTRIBUTION

The relation between rainfall and ground water is complex; For best evidence the records should show the amount of precipitation, the rate of fall, the condition of the land surface at the time, the cloudiness, and the direction and velocity of the wind that follows the rain. Some of these factors cannot be measured accurately but in general we know that slow rate of fall permits a larger amount of water to soak into the ground. Also if the ground is frozen water cannot penetrate it, or even if the ground is baked and hard, the run-off is increased. In addition if the sun shines immediately following precipitation there is likly to be increased evaporation from the surface. Also winds assist in evaporation and this factor is likewise important, Several workers engaged in ground water studies have pointed out the influence of plant transpiration during the growing season, causing loss of grou water, They have also noted the diurnal changes which modify the ground water conditions.

The direct influence of the rainfall on shallow wells is noticeable wherever such wells are in use. During the spring when the rainfall is heaviest, and when, in addition, the snows that hav accumulated on the surface during the winter melt, the ground water level rises notably, often times filling wells nearly to the top an flooding basements and cellars. During the dry summer months, the water table is lowered by evaporation from the surface, by discharg from springs and seeps along lowlands and by transpiration of plan and by water being drawn from wells, During seasons of prolonged dry weather, shallow wells in the State or in certain areas have be known to become entirely dry due to the lowering of the water table This condition existed in Indiana during the dry seasons of 1930-1931, when the water table was lowered appreciably over extensive areas.

The influence of seasonal conditions on the deep wells is not so pronounced and usually is not noticed. In Noble County during the droughts of 1930-1931 the water level in many wells was lowered as much as four feet. The water level is approximately 80 feet below the surface in this area, though of course dependent upo the surface configuration. It is believed that normal rainfall wil ultimately bring the water table to its normal level. Various writers on hydrology havepointed out that in the deeper strata grou water movement is quite slow, and a change in supply caused by seas conditions might not be detected or if observed would appear long a the contributing cause had ceased to exist.

It is known that many deeply buried aquifers are under hydr static pressure from a head at some distant point, and are separate from the surface by impervious beds. Under such circumstances, changes in season or in rainfall in the general location of the wel would have no effect upon the water supply, unless such adverse cli matic changes also affected the supply area from whence the water originally came.

VEGETATION IN RELATION TO CLIMATE AND GROUND WATER

The greater part of Indiana was originally heavily timbered

and at the present time very little virgin timber is left standing in any part of the State. Small areas of prairie land existed in this State west of the junction of the Tippecanoe and Wabash rivers, though these areas were very restricted and joined the vast Illinois prairie on the west. In the woodland area map accompanying this report Benton County is outstanding for its small area of timbered land. This condition has always existed. Northern Indiana at present has many fine groves on farms, though their area is indeed small compared to that which was forested when the State was first settled. Southern Indiana has thousands of acres of small timber, but even this is being culled over rapidly in an effort to sell for commercial purposes those trees large enough for desired uses.

For several years the efforts of the Division of Forestry of the Department of Conservation have been directed toward a constructive working forestry policy. The following is taken from the 13th Annual Report of the Department of Conservation, State of Indiana, Publication 113, 1931. "Indiana now has a working forest policy. This includes the following activities; public acquisition of state forest lands; a tax classification law to encourage private investment in forest enterprise; a law permitting city and county forests; the operation of state nurseries to supply trees for forest planting; a forest fire law authorizing federal, state, and private cooperation in systematic fire protection for forest lands."

Timber and brushwood are believed by some students of the subject to be valuable agents in the conservation of ground water. The thick forest litter and humus soil retain moisture that falls as rain or snow, and the shade of the woods retards evaporation. The run-off is therefore reduced, and a larger quantity of water sinks directly into the ground. Timbered lands act as reservoirs of rainfall, gradually feeding it into the ground, and thus not only equalized but increase the ground water supply and cause the ground water surface to stand relatively high.

In practically every region a part of the water that is removed by evaporation from the soil and by transpiration of plants is derived from ground water in the zone of saturation. In humid regions much ground water is removed by evaporation and transpiration, but the recharge is generally so great that despite these losses the underground reservoirs overflow into the streams and maintain the stream discharge during much of the year.

In Indiana cleared tracts will within a few years be covered with rank growths of bushes and trees. The very fact that vegetation can thrive is indicative of favorable ground water supply and the further fact that the wooded areas, the tracts of virgin timber which still stand, have prospered through the years supports the conclusion that in forested areas the water table is not appreciably lowered.

From the standpoint of water supply, one of the most serious effects of timber eradication as pointed out by Cumings (8) is the change of stream regimen. In forested

(8) Cumings, E. R., The Geological Conditions of Municipal Water Supply in the Driftless Area of Southern Indiana, Proc. Ind. Acad. Sci., 1911, p.142.

areas the streams are usually clear even at flood stage and do not deposit along their lower courses vast quantities of transported sediments. Where reservoirs have been constructed below deforested areas, the ultimate result is the silting up and destroying of storage capacity. In the deforested area the result is gullying and pronounced erosion. This is especially true in the more rugged areas of the State. Also floods increase in frequency and violence.

DREDGING AND LEVEL OF GROUND WATER

In addition to the work of deforestation, another activity of man which has had much to do with the ground water level is dredging and ditching. Since Indiana was first settled ditching has played a prominent part in many areas, especially in the northern part of the state. Large open ditches known as dredges and tile drains which feed the dredges have been placed so as to drain surplus surface waters and ground waters which stood at or near the surface. In several areas of the State local shallow ground water supplies have been perceptibly lowered by the draining action of the large dredges.

Aside from the observed fact that the water table has been lowered in dredged areas, another factor of vital importance is that rainfall does not have time to soak into the ground but is carried rapidly away. This also tends to lower the water table. Immediate run-off is increased in the drained areas and flood stages are heightened and the low water stages are much lower.

Visher(9) has published some interesting data re-

(9) Visher, S. S., Geography of Indiana Agriculture, Proc. Ind. Acad. Sci., Vol. 37, 1927, (1928), pp.112-3.

lating to the artificial drainage situation in Indiana. He reports that there are in Indiana hundreds of miles of open ditches and tens of thousands of miles of drain tile converting many formerly worthless swamps into choice farm lands. A map showing the distribution of the tiled land reveals a notable concentration of tile drainage in the north-central plain, where most of the counties have about half of their areas tiled. Boone, Hendricks, Hamilton, Hancock, Rush, Randolph, and Blackford Counties have over 60 per cent. Tipton County has over 90 per cent. In contrast, none of the south-central or far southeastern counties have as much as five per cent of their land tiled, nor do Vigo, Laporte, and Starke counties. None of the southwestern or the far northern counties has more than 20 per cent tiled,

except Steuben (25 per cent), however, some of those counties have extensive open ditch drainage.

In connection with any discussion of artificial drainage, attention is directed to the occurrence of natural subsurface drainage in the limestone belt of southern Indiana. While this subject will be treated thoroughly in a later discussion, it should be mentioned here. Hundreds of square miles underlain by Harrodsburg, Salem, St. Louis and Sta. Genevieve formations of the Mississippian have subterranean drainage. For the most part the outcrop area of the Mississippian limestones is within the southern Indiana unglaciated area, and the relief of the area would permit better natural drainage than the till plains where artificial drainage is necessary.

It is not within the realm of this paper to enter into the controversial aspects of the dredging situation. It is believed that artificial drainage has made serviceable certain areas within the State. There is compensation for ill effects. Mosquitos, ague, marshy unused tracts and a high water table which had doubtful value are in contrast to present-day cultivated farms, permanent drainage ditches and lowered water table. In the majority of cases where dredging has occurred the glacial till is fairly thick and where the water table has been lowered it is only necessary to dig deeper for still better supplies of water. At any rate the deeper wells are usually considered better from a health standpoint and if dredging has obliterated many shallow, polluted water supplies, that fact alone is a blessing to the State.

SURFACE WATERS

STREAMS

Indiana's natural drainage belongs to two great systems, the Mississippi and the St. Lawrence. It has been estimated that 90 per cent of the State drains to the Mississippi and 10 per cent to the St. Lawrence. The number of square miles draining into the Mississippi is 32,692, and into the St. Lawrence 3,858, according to Tucker(10).

(10) Tucker, W. M., Hydrology of Indiana, Part III, Handbook of Indiana Geology, Dept. of Conservation, State of Indiana, 1922 p. 272

The following table is copied from Tucker's report on the Hydrology of Indiana, and shows the principal tributary streams, their drainage areas in square miles, and the per cent of the area of the State.

Subsystem	Area Square Miles	Per cent of State
Blue of washington and Harrison Counties	471	1.29
Minor Ohio tributaries	4279	11.71
Whitewater	1319	3.61
Patoka	813	2.23
White	11155	30.52
Minor Miami drainage	73	.20
Wabash	11481	31.41
Kankakee	3101	8.48
Total Ohio	32692	89.45

Subsystem	Area Square Miles	Per cent of State
St. Joseph of Lake Michigan	1668	4.56
Maumee	1277	3.49
Calumet and Minor Michigan tributaries	665	1.82
Surface Lake Michigan	248	.68
Total St. Lawrence	3858	10.55
Total Indiana	36550	100.00

According to Dr. Tucker the percents of area of the State are drained as follows: Approximately 64% of the drainage of the State passes through the mouth of the Wabash, 17% reaches the Ohio by other lines, 8.5% reaches the Mississippi through the Illinois River, while slightly over 6% flows into Lake Michigan, and somewhat less than 4% enters Lake Erie. As the rainfall is heavier in the southern part of the State the percent of the run-off would be increased southward and decreased northward. "The chief factors which affect the natural drainage of Indiana are the underlying rock, topography, storage, artificial drainage, rainfall and evaporation. These are inter-dependent. The topography is determined to a great extent by the underlying rock, especially in the southern part of the State. The storage is due to the topography in some parts and to the underlying rock in others. Evaporation is dependent upon the rainfall, topography, mean annual temperature, etc."

In summary the following is quoted from Tucker's report(11) on the water-power resources of Indiana:

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(11) Tucker, W. M., Water Power of Indiana, 35th Annual Report, Indiana Dept. of Geology and Natural Resources, 1910, p. 19

"The Wabash and White Rivers drain the major part of the State. All of the State except the extreme northern and northeastern part drains into the Mississippi. The Maumee, Calumet and St. Joseph rivers drain the northern part into the Great Lakes. The White and Wabash rivers are of much the same character. Both are long streams formed by many tributaries. Both have a slight fall throughout their courses. Both flow off the Wisconsin glacial area and have long valley trains. Blue River, which drains Washington, Harrison and Crawford counties, and Whitewater River, which drains the southeastern part of the State, have much higher gradients than the White and Wabash. They are small streams and partake of the nature of the headwaters of the larger streams. Both these streams have a fairly regular flow. In the case of Blue River this is due to the underground drainage of the Mitchell limestone, while in the case of Whitewater River it is due to the vast amount of glacial gravel deposited at its source.

"No swamps or lakes of any considerable size occur in the southern part of the State. The lowlands along all streams are very valuable farm lands. This fact makes available storage basins very scarce under the present demand for water power. However, if the time comes when the water power will be more valuable than the farm land, good storage basins can be constructed. At the present time the feeder dam with the long head race seems to be the best means of utilizing power on the larger streams."

The individual drainage of each county is discussed in the county unit division of this paper and will not be further treated here.

LAKES AND PONDS

The total area in Indiana occupied by lakes, ponds and surface streams is 510 square miles. It has been estimated that at one time about one-fifth of Indiana was lake surface. This time dates from the Illinoian glaciation. The Illinoian glacial lakes were located south of the Wisconsin glacial limit and west of the driftless area. A few of these fossil lakes have been described. They now for the most part constitute good farming land. They were formed originally by the ponding effect of the glacial debris and usually formed in old or pre-existing valleys, where these valleys crossed from the driftless area into the ice-covered territory.

Some of the more common causes of lakes are wind action, glacial action, damming of streams, cutting off of meanders of streams, and diastrophism. Indiana's lakes are fresh water lakes and most of them are due to glacial action. Within the memory of living citizens the area covered by lakes in Indiana has been considerably reduced. Artificial drainage of swamp lands has lowered the water table in many areas with accompanying lowering of lake levels. Many lakes have been obliterated by natural and artificial causes.

Tucker (12) has pointed out that the existing lakes of

(12) Tucker, W. M., Hydrology of Indiana, Part III, Handbook of Indiana Geology, Dept. of Conservation, State of Indiana, 1922, pp. 393-400.

Indiana are now practically confined to three locations:

> "First, the small river lakes which are along the lower courses of the Ohio, Wabash and White Rivers. Second, a belt of glacial lakes extending from northern Wabash and Miami counties to Steuben County and occupying Wabash, Miami, Fulton, Kosciusko, Whitley, Noble, DeKalb, Lagrange, and Steuben counties. Third, a belt of glacial lakes extending from Fulton to Laporte counties and occupying Fulton, Marshall, Starke, St. Joseph and Laporte counties. The second and third occupy the marginal moraines formed by the Saginaw lobe of the Wisconsin glacier in conjunction with the moraines of the Erie lobe on the east and the Michigan lobe on the west."

The lakes and ponds of the State are fed by surface streams, direct precipitation, and ground water. Visher (13) has stated

(13) Visher, S. S., The Geography of Indiana, Part I, Handbook of Indiana Geology, Publication No. 21, Dept. of Conservation, State of Indiana, 1922, p. 13.

that Indiana contains 36,045 square miles of land area in addition to 280 square miles of rivers and small lakes and 230 square miles of Lake Michigan. The writer is of the opinion that the fact

that the State of Indiana has 230 square miles of Lake Michigan within its boundaries is not generally known.

In connection with the proximity of Lake Michigan which borders three Indiana counties in the northwestern corner of the State should be mentioned the prevalent idea in certain localities that the ground water of northwestern Indiana is supplied by Lake Michigan. Flowing wells in northern Indiana are in no way connected with Lake Michigan and do not obtain a head from the waters of the Great Lakes. The level of Lake Michigan is approximately 581 feet above tide, while most of the surface of northern Indiana is distinctly higher. Some of the valley flats along the Wabash River are lower, but even a surface stream across this area would flow slowly, not taking into consideration the friction of water flowing through rock pores. The mouths of nearly all the flowing wells in northern Indiana are far above the level of Lake Michigan.

The shallow wells of northwestern Indiana which obtain water from the glacial drift could not possibly secure water from Lake Michigan. There is every evidence that there is deep seated underground drainage from the Kankakee valley toward Lake Michigan. The gravel beds of the drift are usually of local distribution and commonly vary greatly in thickness even in short distances. The source of head in such gravel beds must be within the limits of the open bed, which is usually only a few miles or even less across.

Tucker (14) has described some interesting experiments

(14) Tucker, W. M., History of the Lakes near Laporte, Indiana, Proc. Ind. Acad. Sci. for 1922, (1923) pp. 83-94.

made near the north shore of North Pine Lake, Laporte County. By drilling a few wells and charging one with fluorescein it was determined that the ground water was not moving toward North Pine Lake at the surface of the lake, but that the water movement was northwestward at the rate of six feet in thirteen hours, or approximately eleven feet per day.

SWAMPS

Attention has previously been directed to the fact that Indiana when first settled had thousands of acres which needed draining. Many of the pioneers who first settled in the State selected the hilly southern portion. Due to marshes and swamps the northern glaciated section of the State was much slower in development. With the advent of tile draining and open dredging the above situation was reversed and northern Indiana became a rich farming region. Tile draining and dredging are still in progress. Drainage districts, county units, the State of Indiana, and even the Federal Government have aided in this work. The valley flat of the Kankakee River is the most notable undrained area existing in Indiana at the present time.

It has been estimated that there are about 36,000 acres of workable peat beds in Indiana. Most of the peat beds of the State are found in the three northern tiers of counties. The greatest concentrations of lakes are in these same tiers of counties. Peat bogs are mentioned since it is believed that peat accumulates at or near the water table; for, if the water table is lowered, the deposit is exposed to the atmosphere and decomposition results.

Practically every county in the Wisconsin mantled area of Indiana has a few acres of marsh land, and even in the low alluvial flats of the Ohio and Wabash Rivers are found areas in which the water table is more or less permanently above the surface. Floods, which seem to be on the increase, are primarily responsible for the temporary increases in both surface and subsurface water levels. Aside from doing damage at the surface, floods frequently raise the general ground water level to such a height that roots of plants cannot obtain proper aeration and consequently the plants die. In portions of Indiana the main problem is to eliminate excess water and to lower the permanent ground water level of marshy tracts so that they may be cultivated. In other bottom regions, the problem is to remove excess waters during flood times or to prevent the occurrence of flooded conditions. The increase of flood tendency is believed due primarily to the deforestation of large areas in Indiana.

QUALITY OF WATER

There are many areas in Indiana which cannot obtain ground water supplies in sufficient quantities for public use. Many private homes must procure water from cisterns and artificial reservoirs. In the case of cities so located that ground water cannot be dependable as a source of supply or is too highly mineralized, or for other reasons is unpotable, reservoirs must be constructed or river waters used.

In the case of the larger cities of Indiana ground water is not used. The city of Indianapolis uses some ground water from many wells; however, this supply is supplemented with water from White River and Fall Creek. The city of Fort Wayne has found it necessary to abandon 51 wells, which have furnished a supply of water to that municipality for about fifty years, in favor of reservoirs on the St. Joseph River. Evansville has obtained a supply from the Ohio River. Gary, Hammond, East Chicago and other large cities in the northwestern portion of the State use the waters from Lake Michigan. South Bend is the only city in the 100,000 class which procures water from underground sources entirely. Terre Haute, Bedford, Columbus, Washington, North Vernon, Princeton, Petersburg, Anderson, Logansport, New Albany, Vincennes, Aurora and Seymour are cities which obtain water from river sources. Bloomington obtains a municipal water supply from an artificial lake; also Indiana University at Bloomington has an artificial lake. Some of the Indiana cities which obtain water from wells are Marion, Frankfort, Angola, Attica, Auburn, Bicknell, Bloomfield, Spencer, Bluffton, Brownstown, Columbia City,

Connersville, Fowler, Greenfield, Greensburg, Hartford City, Lafayette, Jeffersonville, Kokomo, Westville, Pendleton, Martinsville, Laporte, Lebanon, Franklin, and Mishawaka. This list does not include all Indiana towns utilizing ground water. For a more complete statement in regard to any particular town the reader is referred to the section on public supplies accompanying last county report.

As population increases the surface waters will be more extensively used. Surface waters have the disadvantage of being turbid and exposed to pollution so that they require purification, which is not necessary for deep well waters. Many of the river waters used by Indiana cities require plants for the removal of sediments in addition to filtration and purification plants. Chlorination is the most used purification process. Surface waters are generally not as hard as ground waters, though surface waters which come in contact with limestone dolomites, and glacial drift consisting of reworked, surface materials, is likely to be highly charged with minerals and almost as hard as ground water. In most cases the dissolved mineral matter in the surface waters is not very different in quantity or quality from that in ground water in the neighborhood. This applies in particular to the ground water in the upper strata, and not the ground water at depth.

The analyses in the accompanying table show the chemical character of some surface waters in Indiana. The following information and tables are taken from Water-Supply Paper 254 by S. R. Capps: (15)

(15) Capps, S. R., The Underground Waters of North-Central Indiana: Water-Supply Paper U. S. Geological Survey No. 254, 1910, pp. 262-5.

"From August, 1906, to September, 1907, daily samples of water were collected from streams in or near the region under discussion and united in sets of ten consecutive samples, and analyses of the composites thus obtained permit computation of maximum, minimum, and average conditions. The results in detail have been published in Water-Supply Paper 236.[c]. Samples of water

[c] Dole, R. B., The quality of surface waters in the United States, pt. 1: Water-Supply Paper U. S. Geol. Survey No. 236, 1910.

from Wabash River at Logansport were collected by Mr. John Bender in midstream above the entrance of Eel River; lines A, B, and C in the following table give the mean, maximum, and minimum values, respectively, of the estimates. Wabash River was examined also at Vincennes, where Mr. L. J. Weisenberger collected samples from the waterworks intake. The mean, maximum, and minimum values for the water at Vincennes are given in lines D, E, and F. At Indianapolis samples of water from West Fork of White River were taken in midstream under the direction of Mr. H. E. Jordan. Lines G, H, and I show the mean and the limits

during the year for White River at Indianapolis. East Fork of White River was tested at Azalia, where samples were collected by Mr. L. E. Davis, and the summarized results are reported in lines J, K, and L. For comparison the average quality of the water of Lake Huron is given in line M, as computed from analyses of 12 monthly samples taken at Port Huron, Mich. The percentage composition of the anhydrous residues, computed from the mean quality of the same water, is reported in lines N, O, P, Q, and R thus: Line N, percentage composition of the anhydrous residue of water from Wabash River at Logansport; line O, the same from Wabash River at Vincennes; P, West Fork of White River at Indianapolis; Q, East Fork of White River at Azalia; R, Lake Huron at Port Huron, Mich.

A, B, C. Wabash River at Logansport; analyses by W. M. Barr, H. S. Spaulding, and Walton Van Winkle.
D, E, F. Wabash River at Vincennes; analyses by W. M. Barr, H. S. Spaulding, and Walton Van Winkle.
G, H, I. West Fork of White River at Indianapolis; analyses by W. M. Barr, H. S. Spaulding, and Walton Van Winkle.
J, K, L. East Fork of White River at Azalia; analyses by W. M. Barr, H. S. Spaulding, Walton Van Winkle, R. B. Dole, Chase Palmer, and W. D. Collins.
M. Lake Huron at Port Huron, Mich.; analyses by R. B. Dole and M. G. Roberts.
N, O, P, Q, R. Percentage composition of the anhydrous residues computed from A, D, G, J, and M, respectively.

"The most noticeable feature in the foregoing table is the unusually high mineral content of Wabash River at Logansport, which averages 807 parts per million, as compared with 466 and 467 for the ground waters of the same region; another noticeable feature is the great fluctuation in mineral content, which ranges from 309 to 1,940 parts per million. From line N it can be seen that the water is particularly high in alkalies and chlorides, and inspection of the individual analyses shows that high chlorides and alkalies are always coincident with high total solids. The chief reason for these phenomena is undoubtedly varying pollution by salt water from oil wells, as noted on page 261, because surface waters from regions similar to this in rainfall and rock formations have not this peculiar composition. Wabash River and its southern tributaries above Logansport, the Mississinewa and the Salamonie (see Pl. I), receive a large amount of drainage from the oil belt, and physical evidence of this pollution, such as oil-stained and blackened vegetation, is encountered in the beds of streams. The scale formed in boilers using such water would be hard, and the water would also foam and corrode the boilers; at times of highest mineralization the water is unfit for boiler use. Though Vincennes is not in the region under discussion, analyses of the river water at the city have been introduced in order to show the improvement affected by dilution. The great change in concentration can be appreciated by comparing lines A and D.

Quality of the surface waters.

(Parts per million, except as otherwise stated.)

Table 1

	Turbidity	Suspended matter	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na & K)	Carbonate radicle (CO_3)	Bicarbonate radicle (HCO_3)	Sulphate radicle (SO_4)	Nitrate radicle (NO_3)	Chlorine (Cl)	Total solids
A...	132	117	14	0.23	82	35	142	0.0	234	79	5.9	292	807
B...	900	802	38	1.2	133	77	478	7.9	317	138	18	960	1,940
C...	Tr.	Tr.	5.0	Tr.	43	15	22	.0	116	42	.0	35	309
D...	172	193	13	.24	61	22	25	.0	230	55	6.4	36	336
E...	625	656	36	1.8	75	30	60	.0	264	73	18	104	504
F...	15	18	3.0	Tr.	45	15	8.1	.0	147	37	1.1	8.3	209
G...	39	38	14	.15	74	29	48	.0	291	58	6.1	78	450
H...	235	124	27	.8	95	43	138	6.5	353	125	14	262	798
I...	Tr.	Tr.	8.4	Tr.	48	17	14	.0	205	36	.5	13	245
J...	52	48	15	.14	61	23	9.5	.0	276	30	5.6	3.1	279
K...	245	240	29	1.2	70	29	16	12	320	40	12	8.0	334
L...	3	Tr.	6.6	Tr.	42	15	5.2	.0	176	18	.5	1.3	196
M...	Tr.	Tr.	12	.04	24	7.0	4.4	1.8	100	6.2	.4	2.6	108

PERCENTAGE COMPOSITION OF THE ANHYDROUS RESIDUES

N...	....	....	1.8	a.0	10.7	4.6	18.5	15.1	.....	10.3	.8	38.2	.....
O...	....	....	3.9	a.1	18.4	6.6	7.5	34.1	.....	16.6	2.0	10.8	.....
P...	....	....	3.1	a.0	16.4	6.4	10.7	31.8	.....	12.9	1.4	17.3	.....
Q...	....	....	5.3	a.1	21.5	8.1	3.3	48.0	.....	10.6	2.0	1.1	.....
R...	....	....	11.1	a.0	22.3	6.5	4.1	47.4	.....	5.8	.4	2.4	.....

[a] Fe_2O_3

West Fork of White River at Indianapolis gives evidence of some oil-well drainage, but not to so great extent as Wabash River. (See lines G, H, and I.) The mean quality of this water is strikingly similar to that of the underground water. It differs principally in being higher in chlorides and alkalies and correspondingly lower in bicarbonates. As a source of industrial supply it is far superior to Wabash River at Logansport. East Fork of White River, sampled at Azalia, is not contaminated by oil wells, and its water is more or less typical of what the other rivers would be in their normal or unpolluted state and of streams in this section that do not receive oil-well drainage.

SUMMARY

"Figures representing the average chemical composition of the principal sources of water supply in this region are given in the following table. Line A shows the average of five analyses of waters from the lower limestones; line B, the average of 83 analyses of waters from the upper limestones; line C, the average of 169 analyses of waters from the unconsolidated deposits. The average mineral contents of the waters of the Wabash at Logansport and the White at Indianapolis are given in lines D and E, respectively.

"The chief points of interest in this table (2) are the high mineralization of the waters from the lower limestones and from Wabash River and the great similarity in composition of the waters from the upper limestones, the drift, and White River. As stated in the previous paragraphs, however, it should be recognized that the river waters fluctuate a great deal in composition and that the waters of local wells differ greatly from one another."

Average quality of waters in north-central Indiana

(Parts per million) Table 2

	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Carbonate radicle (CO_3)	Bicarbonate radicle (HCO_3)	Sulphate radicle (SO_4)	Nitrate radicle (NO_3)	Chlorine (Cl)	Total solids
A....	14	0.7	205	104	820	0.0	400	170	....	1,570	3,890
B....	18	1.8	82	31	27	.0	341	70	1.0	19	466
C....	18	.8	91	31	18	.0	306	76	2.8	47	467
D....	14	.2	82	35	142	.0	234	79	5.9	292	807
E....	1	.2	74	29	48	.0	291	58	6.1	78	450

GROUND WATERS

SOURCES

The rocks which underlie the surface of Indiana are saturated with water below a level known as the water table, which ranges from the surface to a depth of 100 feet or more, The water table is deepest in some of the higher parts of the upland areas and is shallowest in the lowlands. In swamps and marshes the water table lies continuously or intermittently above the surface of the ground. In northern Indiana where the lakes are so abundant, the water table is near the surface. The water table does not occupy a fixed position at any given place but fluctuates continually, being highest just after a period of prolonged precipitation and lowest at the end of a long drought. The water table has irregularities comparable with and related to those of the land surface, although it is less accentuated.

By definition the water table is the upper surface of the zone of saturation in ordinary permeable soil or rock. The beds between the surface and the zone of saturation are said to be in the zone of aeration, which may contain either water or gases. It is necessary for wells to penetrate the water table if they are to be productive and even then other factors may prevent the well from being a source of water. The stratum in which the water table occurs may be a compact, fine even-bedded shale or similar formation that will not give up water readily. Coarse sandy or gravelly deposits with large pore spaces contain and give up ground waters most readily. The shales just described retain water tenaciously within their interstices, are not aquifers and are not considered as water-bearing formations. In such cases it is necessary to drill to more porous horizons or be content with a seep well.

The greater part of the ground water of Indiana is derived from precipitation within the borders of the State. It is true that several streams, notably the Wabash Salamonie, and perhaps a score of small tributary streams enter from Ohio, Michigan, and Illinois. The Ohio River separates Indiana from Kentucky, so that Kentucky cannot be considered. The Wabash River serves as the boundary between Illinois and Indiana, beginning about ten miles below Terre Haute, so approximately 125 miles of Indiana-Illinois boundary is eliminated. Also approximately 50 miles of Lake Michigan serves as State boundary of Indiana. Itis doubtful if those streams which enter Indiana from Ohio, Michigan and Illinois contribute appreciably to Indiana's ground water supply. When it is considered that such streams as the Maumee, St. Joseph, Kankakee, Iroquois, Wabash, Whitewater, Blue, and many tributaries flow directly into other states or main rivers which affect neighboring states as much as they do

Indiana, it is a foregone conclusion that Indiana's contribution both in surface and subsurface waters exceeds the gains, from adjacent areas.

About 30,100 square miles of Indiana have been modifie by glaciation, while only about 6,250 square miles have remained untouched by glacial action. This means that practical five-sixths of the surface area of the State is mantled with deposits of glacial debris. Rain water which falls on the surface has a chance to penetrate the glacial covering, provided the precipitation falls slowly and other factors are favorable In this manner it is believed that precipitation reaches the bedrock and deeper formations. Where formations outcrop withi the State, precipitation has an opportunity to penetrate the strata directly, provided they ar porous, and may go down the dip for miles before again coming to the surface. Beneath the glacial mantle the bedrock in contact with this mantle usually obtains an abundant supply of ground water. Unless the bedroc is impervious shale or siltstone, or other conditions cause it to be impervious so that water connot penetrate the pores, thi upper bedrock zone immediately underlying thick drift is an excellent aquifer. In many areas the formation immediately below the drift is not an aquifer, so that deeper drilling or s ping at the bedrock must be the plan adopted. A case in point is that at Fort Wayne. Cumings(16) has described the cuttings

(16) Cumings, E. R., Silurian Studies -- Two Fort Wayne Wells the Silurian, and Their Bearing on the Niagaran of the Michiga Basin, Proc. Ind. Acad. Sci., Vol. 39, 1929, (1930), pp. 183-9

and interpreted the geologic section of two wells drilled by the Fort Wayne Water Works. Well No. 1 penetrated 110 feet of glacial drift, a thin stratum of Greenfield dolomite and then 450 feet of Huntington dolomite, including the New Corydon. The Huntington dolomite at this location is a white, granular, medium-grained, often saccharoidal dolomite. Well No. 2 penetrated 70 feet of glacial drift, 40 feet of Greenfield dol mite which was fine-grained, and then went through 450 feet of very fine to finely crystalline, saccharoidal dolomite of Huntington age. One cannot fail to be impressed with the rela tive imporosity of these strata. These sub-drift formations w not aquifers and at depths of 640 and 630 feet the wells were abandoned with no water prospects imminent. For a period of fifty years the city of Fort Wayne had obtained water from the glacial drift or from the porous dolomite at the contact of the drift and bedrock. Deeper penetration into the bedrock gained additional water, but apparently reduced the supply from existi wells. For a more complete statement in regard to the Fort Wa system, the reader is referred to the Allen County section per taining to municipal supplies.

There is some basis for the idea that many water horiz still exist as they were originally buried in the sediments. Such deposits are said to contain fossil waters or connate wat Connate waters may have been originally fresh or marine. Owin

to an impervious covering, both above and below such waters have retained their original characteristics to a marked degree. Salt water has retained its saline content. It is conceded that connate waters may exist with the proper geological conditions, though actual existence of such waters may admit of a variety of explanations. Fresh water perhaps would not continue fresh through geological ages.

The ideal geological conditions for the continued preservation of connate waters would exist in the Illinois-Indiana coal basin, which subsurface records show to be centered west of Gibson County, Indiana. In this basin waters both connate and foreign would be entrapped because of the lack of any outlet. Concentration of the original brines would result. It must be kept in mind that movement of ground waters at great depths is exceedingly slow. It must be concluded that ground water is practically static when saturation occurs at great depths, in strata of low dip and which are near the natural outcrop so that great pressure cannot be maintained by any great differences in elevation.

The Borden group of rocks assigned to the basal Mississippian of Indiana consists of a series of sediments which contain but little ground water and part with it reluctantly. Springs and seeps are relatively rare in the Borden outcrop belt. Wells obtain some water, though many of the wells barely supply a household and even then a number of the Borden wells bear saline waters, unfit for use. Many of the creeks in the Borden outcrop area are intermittent and become dry after the rainy seasons. Salt licks are frequented by cattle in many localities in which the Borden strata occur. Early Indiana Geological Survey reports state that salt was made from brines obtained from the springs and wells of the area. No strata of salt are known to occur in this part of the geological section in Indiana. From whence came the salt? Some geologists assert that connate water is the answer, that these salt waters are the original sea brines incorporated within the sediments at the time of their deposition. There is no doubt that the Borden sediments were deposited under marine conditions. The contained fossils of marine origin testify to that conclusion. Another suggestion in regard to the origin of salt water is that the salt crystallized from the original sea water and was later dissolved by circulating ground waters. Present day well experience indicate that water does not circulate freely through the Borden, though the existence of springs and wells shows that there is some movement of the water. An analysis of the New Providence(17) shale indicated the presence of 4.54 percent of water.

(17) Blatchley, W. S., The Clays and Clay Industries of Indiana, Ind. Dept. of Geology and Natural Resources, 29th Annual Rept., 1905, p. 367.

It has been stated in a previous discussion that Indiana obtains no ground water from Lake Michigan. Also, the rivers do not act as feeders to the ground water along their courses, but obtain ground water from adjacent areas. Lakes of Indiana are fed from ground water. From whence comes

the ground water? The greater part of the ground water of Indiana is derived from precipitation within the borders of the State. A few deeply buried formations may receive some water from areas outside the State, and sea water probably still exists in large quantities in some of the deeply buried formations and in a few of the outcropping formations. As some of the geological formations that underlie the surface in Indiana are composed of dense shale, limestone, and dolomite and as other intervening formations are composed of porous sands and jointed limestones, it follows that rain water which falls on the surface will be readily absorbed by the more porous strata and will pass by gravity down the gently inclined buried beds of a porous nature between the denser and relatively impervious beds. By this process quantities of water have become stored in the formations and constitute a valuable resource.

SPRINGS

The State of Indiana has gained a reputation far and wide for natural springs and their waters. It is true that mineral springs and advertising are largely responsible for the national recognition given the State in this respect, nevertheless certain springs are distinctive. The famous springs at French Lick and West Baden in Orange County, Indiana, and Trinity Springs in Martin County, Wilson's Spring now called Harrison's Spring in Harrison County, and the Fish Hatchery Spring at Avoca in Lawrence County are among the springs which have attracted the attention of people far beyond the boundaries of Indiana. The location, origin and character of mimeral waters in Indiana have been discussed by Blatchley,(18) and by Logan(19) from an economic standpoint.

(18) Blatchley, W. S., The Mineral Waters of Indiana, 26th Annual Report, Indiana Department of Geology and Natural Resources, 1901,pp. 11-226.

(19) Logan, W. N., Economic Geology of Indiana, Part V, Handbook of Indiana Geology, Publication 21, Dept. of Conservation, State of Indiana, 1922,pp. 781-94.

It would be interesting to know the number of citizens of Indiana who secure their water supply from springs, but no accurate figures are available. Many private supplies and several town supplies come from springs. Most of the springs emerge at the outcropping contacts between relatively impervious strata, such as clay, shale or dense limestone or dense sandstone, and overlying water-bearing sands or limestones. Springs usually form an ideal source of farm supply where caution has been exercised with respect to pollution. In the more hilly regions of southern Indiana, where farm buildings and homes have been located in valleys, it is found frequently that a nearby spring has been the determining factor in the choice of the location.

Natural spring water is almost never dangerous to health, because the minerals it contains in solution are generally harmless. In a few cases the waters act as a laxative and others contain sulphur in amounts that make the water unfit or disagreeable.

The term "spring" is properly applied to any water naturally emerging from the ground at a single point or within a restricted area. The distinction between springs and general seepage, however, is not always very sharp. Springs are classified in various ways. Fuller(20) states that springs may be divided according to their mode of origin, into gravity and artesian springs, and, according to the nature of the passages traversed by the water, into seepage, tubular, and fissure springs.

(20)Fuller, M.L., Underground Waters for Farm Use, U.S. Geol. Survey Water-Supply Paper No.255, 1910, pp. 22-7.

Gravity springs. -- A gravity spring is one fed from porous materials unconfined by impervious strata. Water flows by gravity to lower levels, just as a surface stream flows. Many of the springs which issue from glacial drift and alluvial deposits are of this type. Gravity springs generally bear fresh water, and are seldom highly mineralized.

Artesian springs. -- An artesian spring is one whose waters are under hydrostatic pressure because of the source of the waters being greater in elevation than the spring. It is necessary to have the water confined between impervious layers or conduits of some type.

Seepage springs. -- Seepage springs are usually gravity springs in which water seeps out of sand or gravel slowly. They are of limited areal occurrence which distinguishes them from general seepage. Fuller(21) has pointed out that seepage springs are commonly of the gravity type, but where channels or fissures emerge beneath beds of sand or gravel seepages not infrequently result from true artesian springs.

(21) Ibid., p. 23.

Tubular springs. -- Tubular springs are quite common in the driftless area of southern Indiana because of the solution in the limestone strata. Conduits for water are made in various ways. Daily passage of water through a porous stratum frequently causes a channel to form and eventually a tubular spring results. Seeps frequently become springs of the tubular type. It can be seen that this type includes both gravity and artesian springs.

Fissure springs.-- Fissure springs include those issuing along bedding, joint, cleavage, and fault planes. This type indicates that a break has occured in the strata permitting water to escape. Most springs of this type are from considerable depths and many are highly mineralized. The springs at West Baden and French Lick are of this type. Frequently fissure springs bear water with high temperature, indicating derivation from considerable depth. No such thermal springs are known in Indiana. Hot Springs, Arkansas, and Steamboat Springs, Nevada, are examples of this type. The latter mentioned has steam escaping at the surface.

Many Indiana wells produce warm sulphur water, but while frequently alluded to as Mineral Springs, strictly interpreting the facts of the occurrence they are not springs but wells.

Other classifications of springs exist. Some are as follows: deep and shallow; cold and thermal; intermittent and permanent; mineral and common. Mineral springs are often named for the chief type of mineral matter contained in solution, as sulphur, chalybeate, calcium, soda, and iron. Medicinal springs are those which contain substances which have actual or fancied curative properties.

Most of the springs of Indiana emerge at the outcropping contacts between relatively impervious strata such as shale, dense limestone or clay and overlying water-bearing beds. Springs usually occur at the heads of small valleys, on slopes or in valle flats. Indiana's springs range from those which flow as seeps and intermittently, to those of the type of Wilson's Spring in Harriso County which has been estimated to flow as much as 10,000,000 gallons per day during the dry season. If the rise of Lost River in Orange County be considered as a spring, it is the largest in Indiana, flowing several million gallons per hour.

ARTESIAN WATERS

Definition

The word "artesian" has been used with several meanings. At first the term included simply the superficial phenomena of flowing wells. At the present time the term artesian waters incl not only the water of flowing wells, but also well waters that ri to a considerable height within the tube or casing, under hydrostatic pressure. The structural relations of the aquifer, the associated impervious strata which permit ground water movement and hydrostatic pressure are the factors which make artesian cond tions. An artesian well is, therefore, a well in which the water rises considerably above the ground water table by natural hydrostatic pressure, as a result of certain structural conditions. Depth and diameter do not necessarily enter into the conditions necessary for artesian wells. While it is true that many deep wells are artesian, it is also a fact that many shallow glacial drift wells are artesian. The term "flowing well" is usually applied to that type of well whose waters overflow, and the others are generally termed "non-flowing wells."

The height at which artesian water stands under hydrostatic pressure is called its static level or head. It may be ex pressed in its relation to sea level, to the level of the water t or to the level of the well mouth. The latter is used in this report. If the head of the artesian well is above the mouth of t well, there results a flowing well; if the head is below the

mouth of the well, the non-flowing type of well occurs.

NECESSARY CONDITIONS FOR ARTESIAN WELLS.

The theory of artesian wells is well known and generally accepted. As far back as 1729(22) artesian conditions were recognized and the principals of occurrence stated. The conditions have been ably restated by a number of American geologists, and particularly, by Chamberlin (23) and by Fuller.(24)

(22) Norton, W.H., Artesian Wells of Iowa, Iowa Geol. Survey, Vol. VI, 1897, p. 128.

(23) Chamberlin, T.C., The Requisite and Qualifying Conditions of Artesian Wells, U.S. Geol. Survey, Fifth Annual Rept., 1884, pp. 125-73.

(24) Fuller, M.L., Summary of the Controlling Factors of Artesian Flows: U.S. Geol. Survey Bull. 319, 1908.

Chamberlin has stated the requisite conditions upon which artesian flow depends as follows:

"1. A pervious stratum to permit the entrance and the passage of water.

2. A water-tight bed below to prevent the escape of the water downward.

3. A like impervious bed above to prevent escape upward, for the water, being under pressure from the fountainhead, would otherwise find relief in that direction.

4. An inclination of these beds, so that the edge at which the water enters will be higher than the surface at the well.

5. A suitable exposure of the edge of the porous stratum, so that it may take in a sufficient supply of water.

6. An adequate rainfall to furnish the supply.

7. An absence of any escape for the water at a lower level than the surface at the well."

Fuller has stated that the above requisites apply more particularly to flow from stratified rocks and fail to include flows from other types of rock or even types of flow from the same rock. He calls attention to many exceptions to the above limitations and suggests more comprehensive essential conditions as follows:

"1. An adequate source of water supply.

2. A retaining agent offering more resistance to the passage of water than the well or other opening.

3. An adequate source of pressure."

Simpson(25) has stated that every system of waterworks that uses a gravity method of distribution is an illustration of the principle and functioning of artesian conditions. Water is supplied by the pumps to an elevated tank, from which it is run by gravity through the mains to the delivery pipes. The water rises into homes and factories and to other outlets under a pressure proportional to the relative height of the water in the main elevated tank. Mr. Simpson is quoted as follows:

(25) Simpson, H.E., Ground water Resources of North Dakota, U.S. Geol. Survey Water-Supply Paper 598, 1929, p. 48.

> "Thus we see that there is nothing mysterious about artesian water. The reason for its flow is as easily understood as that of the water from a tap or fire hydrant connected with the village waterworks, because the principle is the same. If all taps and hydrants in the village system were allowed to stand open, the supply in the reservoir would very soon be exhausted and then only a few of the lowest taps in the village would flow, since a few open taps can drain away the water as fast as it is pumped into the system. The same is true of an artesian system; if all wells are left wide open to flow to waste, the reservoir of sand or sandstone is soon drained and the wells, except perhaps those on very low ground, cease to flow. A few wells may waste all the water which enters the artesian reservoir from rainfall."

ARTESIAN CONDITIONS IN INDIANA

The conditions that govern the occurrence of artesian water in Indiana may be summarized as follows:

1. The main source of the water in the artesian systems is the rain that falls upon the surface within the borders of the State or in adjacent areas.

2. The retaining agents are chiefly layers of dense limestone, shale, clay, fireclay or siltstone, which dip gently to the southwest on that side of the Cincinnati Arch, and to the north and northeast on the eastern side of the Cincinnati Arch.

3. The water generally is contained in porous layers of sandstone, glacial drift, limestone, dolomite, coal and alluvium.

4. The artesian pressure in any part of a water-filled stratum or bed is due to weight of the water in the same bed at higher levels.

5. Conditions favorable to the occurrence of artesian water are present throughout Indiana, but wells located on uplands do not overflow in many instances owing to the elevation.

The geologic structures in Indiana which give rise to artesian conditions are artesian basins, artesian slopes and topography.

The artesian basin of Indiana is that portion of the Interior Coal Basin which is in the southwestern part of the State. It is typical of an artesian basin. Alternating permeable and impermeable layers are laid down on a basin-shaped floor so that they slope from all sides toward the center. Another type of artesian basin occurs in eastern Allen County. Lake Maumee was an old lake whose bed was composed of glacial materials. This was a drainage area to the northeast and had a pre-glacial stream. It is believed that glacial materials were deposited on this concave floor. Sands were deposited in the lake and then covered with clay. Wells driven into the sandy horizons in the lower parts of the basin produce water which filtered through from the margins of the sand layers. This Lake Maumee region may be a special type of artesian basin. The central depression was the old river valley that opened northward, over which was spread a thick layer of glacial drift and later a thick bed of lake silt. Both glacial and lake deposits contain beds of sand that slope toward the axial valley. Red River Valley in North Dakota is of this type. It is a modified form of the basin since it slopes northward. There is no basin rim on the north side. Also, this type resembles the artesian slope, since the valley is a pitching syncline.

The artesian slope is the common structural feature which has an important bearing on water head. Indiana is underlain by rocks which have gentle monoclinal dip. The rocks of the State dip to the southwest, north, and northeast. The oldest strata are found on the top of the Cincinnati Arch in the southeastern part of Indiana. The formations were laid down on the margin of an old sea floor and this is responsible for the gentle dips from the higher outcropping area toward a lower area. The entire region has been uplifted to form our present upper Mississippi Valley artesian system.

Wells in eastern Allen County and in Gibson and Posey counties illustrate the artesian basin type. The Martinsville mineral wells occur on an artesian slope. The Allen County, Lake Maumee area wells show the modified form of slope and basin type of artesian system.

Another set of conditions, which produces artesian pressure is dependent upon the higher position of the water table in a hill or upland, as compared with an adjacent valley or lowland. Topography is responsible for such artesian conditions. Water pressure is downward and the water table conforms to the topography in a general way. It is probable that many of the artesian wells near moraines are of this type. Stratified rock are not necessary to fulfill these conditions, though they could produce similar occurrences of artesian flow.

QUANTITY

The quantity of water obtainable from underground sources

in Indiana by means of wells or water mines differs greatly from place to place and at different depths, depending upon the local geologic and hydrologic conditions. Texture and porosity vary vertically and horizontally, thus causing differences in the water bearing and water-retaining capacity of individual beds. Many factors enter into the reasons for excellent wells in one spot and failures in an adjacent area. The mechanical construction of the well is a vital point in the success or failure of any well.

At most places it is practicable to obtain from wells the relatively small amounts of water needed for domestic and ordinary farm uses. This same statement applies to the smaller cities and towns, with the exception of some located in the driftless area. Natural springs furnish several southern Indiana towns with public supplies, and many rural and small town domestic supplies are obtained by means of cisterns.

In places the quantity of water available is very large, as shown by the following examples: At Thorntown, in Boone County approximately 1,300,000 gallons of water are furnished daily from three gravel wells. When it is considered that Thorntown has a population of 1325, this gives an average of almost 1000 gallons per day per citizen. It has been stated that ordinarily in a city where there is not much manufacturing, 40 gallons per capita per day is sufficient for all ordinary needs. The city of Elkhart with a population in 1930 of 32,949 obtains a municipal water supply from ten wells which are estimated to produce 12,440,000 gallons daily or are capable of this production. Contrast this supply in Elkhart with that of the city of Goshen,(population 10,397) which reports twelve wells producing 1,000,000 gallons per day. Both city supplies are from coarse gravels in the glacial till. These two city supplies well illustrate the differences in ground water existing between localities which are not far separated. At Marion in Grant County, a well drilled to a depth of 130 feet tested 330 gallons per minute. (See picture on opposite page.) Another picture (Fig. No.) shows a well which was drilled for Ball Bros. Co. at Noblesville, Indiana for a strawboard mill. This well is reported to produce at the rate of 1000 gallons per minute. The city of Greenfield, Hancock County, with a population of 4,188, reports two wells producing 1,500,000 gallons per day. Newcastle population 14,027, located in Henry County, reports five wells producing 2,500,000 gallons per day from glacial drift.

In some parts of the State where the yield of wells has been large and the wells have been numerous, it has been demonstrated that the quantity of available water from the beds now being drawn upon is limited and that at the present rate of removal the supply will eventually be exhausted or at least become of insufficient quantity. This was demonstrated at the city of Fort Wayne. An increasing population plus industrial expansion and accompanying needs coupled with a lowering water table made clear the necessity for action looking toward adequate supplies.

In every case before abandoning public supplies which have been suspected of depletion, it is urged that engineers be employed to study the history of old wells, spacing of wells and the general ground water situation. Frequently a study of a public water supply will reveal other causes for depletion than the lowered water table.

QUALITY OF GROUND WATER

The waters of Indiana range in quality from excellent waters that contain less than 300 parts per million of dissolved solids to those that contain more than 10,000 parts per million. Most of those that are low in mineral content are entirely satisfactory for all ordinary uses, whereas those that are high in mineral content are unfit for domestic, industrial or farm use.

In general most of the waters fall into one of three classes -- first, slightly and moderately concentrated calcium bicarbonate waters having moderate carbonate hardness; second, highly concentrated calcium or calcium-magnesium sulphate waters with considerable noncarbonate hardness; third, highly concentrated brines or sodium chloride-sulphate waters.

Most of the waters of the first class are of meteoric origin and in Indiana occur in the glacial drift and in shallow wells in the limestones and upper bedrock formations. The Borden group and the New Albany black shales occupy a vast area in Indiana either at the surface or adjacent to the mantle of drift. Waters do not circulate freely through the formations of these groups. Likewise shales in the Ordovician, Silurian, Chester of the Mississippian and shales in the Pennsylvanian do not permit circulation. Therefore it is seen that circulating meteoric waters of the first class, while abundant are not without limits.

The waters of the second and third classes cannot always be differentiated. They occur at greater depths in permeable beds or moderate depths in beds of low permeability. The brines are probably connate in origin or modified connate waters originating in a period of marine sedimentation. It is believed that the Mississippian (Borden group) strata contain connate waters. Salt was extracted from brine in Brown County many years ago and even today many salt licks and briny waters occur in this area.

Another interesting occurrence in Indiana is the waters that are high in sulphates of magnesium and calcium. The Springs at West Baden and French Lick are typical of this occurrence. It is believed that these waters owe their high concentration to slow percolation or stagnation in strata containing soluble sulphates or perhaps to the reaction on limestone of sulphuric acid formed by the decomposition of pyrite. Much pyrite is known to occur in the Mississippian limestone formations and oxidation and hydrolysis of pyrite would produce acid to decompose the limestone. In general this decomposition does not occur at the surface but at depth.

The increasing percentage of dissolved minerals at increasing depths has often been noticed. In Indiana the very deep formations invariably contain briny waters or sulphur waters unfit for use. For this reason deep drilling cannot be encouraged. There are exceptions to this statement. It is not true that all deep wells carry nonpotable waters. In the Unionville gas field of eastern

Monroe County, fresh water was found in the Devonian limestone. Salt water was expected at this horizon. The structural conditions of the field are believed to be responsible for this freshening of the water. It is not a normal condition and is perhaps best explained by proposing a theory that fresh water along the fault-plane permitted the deeper water to freshen.

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3. Blatchley, W.S., The Mineral Waters of Indiana: Indiana Dept. of Geology and Nat. Res. Twenty-sixth Ann. Rept., pp. 11-158, 1903. (This annual report gives on pp. 159-226 an article by Robert Hessler on the medicinal properties and use of Indiana waters.) Eighty analyses from miscellaneous sources.

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5. Collins, W. D., The Industrial Utility of Public Water Supplies in the United States, U.S. Geol. Survey Water-Supply Paper 496, 1923, pp. 34-6 pertain to Indiana city supplies.

6. Logan, W. N., Tabulation of Analyses of Indiana Mineral Waters, contained in Economic Geology of Indiana, Part V, Handbook of Indiana Geology, 1922, pp. 789-94.

CLASSIFICATION OF WATERS

DOMESTIC USE

Sanitary Considerations. -- The chemical analyses given in this report furnish no criteria for opinions in regard to the sanitary quality of the waters examined. Statements made in regard to domestic use of the waters refer to the use as affected by the dissolved mineral constituents and do not take into account possible pollution by disease-producing bacteria.

The possibility of pollution can best be determined by inspection of the surroundings. Surface waters, shallow wells, surface conditions at all wells, and many springs require special care to prevent contamination. Deep wells are usually safer, and when contaminated the source can usually be traced to surface water that may enter at the curb or through defective casing.

Under a rule of the State Board of Health, adopted May 21,1930, it is required that operators of public water supplies submit samples to the laboratory at intervals specified by the State Health Commissioner. Acting under the authority of this rule a sampling schedule or interval has been established for each supply. It is interesting to note that statistics show that ground water is the source of the majority of the questionable supplies found.

Dr. J. W. Beede (26) in a paper read before the Indiana State Board of Health, has shown that old adjustments are broken as the water table is lowered, thus causing what once was good water to become unfit for use. In Indiana the drought of 1930 and 1931 was responsible for the lowering of the water table and this reason is assigned in a large measure for the failure of several of the public supplies to meet the required bacterial standards.

(26) Beede, J. W. (Cited) by Bybee and Malott -- The Flood of 1913 in the Lower White River Region of Indiana -- Indiana University Studies Bulletin Vol. XII, No. 11, October 1914, p. 212.

Hardness. -- Hardness in water is produced by calcium and magnesium salts, commonly called lime and magnesia. The hardness of a water is most noticeable when used with soap, because insoluble lime and magnesium salts will form and prevent the soap from exercising its cleansing power. The hardness depends on the quantities of calcium and magnesium in the water. Hardness may be recognized also by the deposits of insoluble salts formed when a hard water is heated or evaporated. This is best illustrated by the incrustations on the inside of the old familiar tea-kettle.

A few other elements, such as iron, aluminum, strontium, or barium, would cause hardness, but these are not found in the water of public supplies in quantities large enough to have any sppreciable effect. There are exceptions to this statement, as it is definitely known that at least two or three public supplies in Indiana are treated to remove iron.

Hardness may be determined by the use of a standard soap solu-

tion, but in general can be determined more reliably by calculati
than by the use of the soap solution. Most of the "calculated"
results are obtained by calculations from the calcium and magnesi
In order to have a uniform expression for hardness it is customar
to report it as calcium carbonate ($CaCO_3$) equivalent to the calci
and magnesium. This amount is calculated by multiplying the quan
of calcium by 2.5 and the magnesium by 4.1 and adding these produ

Some textbooks use the formula: TH equals 2.5 Ca plus 4.1 M
In this equation TH, Ca, and Mg represent the parts per million o
total hardness, calcium and magnesium respectively.

If the hardness of water is less than 50 parts per million i
is usually not noticed, and hardness from 50 to150 parts, although
noticeable, does not produce serious inconvenience. Where water
with over 200 parts per million is common many cisterns are built
to store rain water for use in laundry work and wherever soap is
used. According to a map of the United States on which the hardn
of water is shown, Indiana is one of nine states which are classe
as having the hardest water. This map (27) gives the average

(27) Collins, W. D., The Industrial Utility of Public Water Suppl
in the United States, U. S. Geol. Survey Water-Supply Paper 496,
1923. Pl. I.

hardness, by states, of water furnished by public supply systems
over 300 cities in the United States and population, by states, o
the cities considered. The states, besides Indiana, are Illinois
South Dakota, Nebraska, Kansas, Oklahoma, Florida and Arizona. T
states for the most part are the best agricultural states. The h
water, however, makes them less desirable as places of residence

In Indiana the average hardness of the water of the large pu
supplies is from 200 to 500 parts per million. Such waters are
actually hard and in some cities efforts are made to reduce the h
ness. Some Indiana cities along Lake Michigan, Bloomington, whic
secures water from a reservoir fed by streams flowing over Borden
strata, and a few other towns which secure water by impounding pr
cipitation have water which is relatively soft. It is true for t
most part that the ground waters are hard. Waters from the Bordo
or which flow over the Borden may be exceptions to this statemen
but waters from the Borden are rare and in many cases contain sa
in solution in addition to hardness of the usual type.

Iron in water water which is used for domestic purposes is o
agreeable. A small quantity will stay in solution as bicarbonate
in a colloidal state without becoming noticeable. If much is pre
it is likely to separate out when the water stands exposed to the
air. The water becomes turbid at first but clears as the iron se
ties to the bottom of the vessel. If several parts per million
are present, the iron will stain articles washed in the water and
stain will be left on enamel-ware vessels, bath-tubs, lavatories
and other enamel plumbing fixtures. Large quantities of iron are
objectionable to the taste to most people, although certain miner
waters are highly exploited for their therapeutic value due to h
content of iron.

By way of summary, the following is quoted from Professor C. W. Foulk, (28) of Ohio State University:

(28) Foulk, C. W., Industrial Water Supplies of Ohio, Geol. Survey of Ohio, Fourth Series, Bulletin #29, 1925, p. 66

"The objectionable qualities of a water for general household use are sediment, turbidity, odor, color, hardness and iron. The higher the value of these characteristics the worse is the water. A hardness of 100 parts per million is about the upper limit of tolerance. Above that value the use of the water with soap becomes objectionable. Iron should be lower than 0.5 part per million or brown spots will appear on laundered clothes and bath room and kitchen equipment will be stained where the water drips on it."

In the operation of steam boilers the commonest trouble due to water is the formation of scale. In a general way the scaling tendency of a water is proportional to the hardness. Mineral matter in solution or suspended in the water deposits on the tubes or shell of the boiler as the water is used for making steam. Those separated solids which adhere to the walls of the boiler are known as scale and the portion that does not adhere but remains as a loose mud is called sludge or basic sediment.

Temporary or carbonate hardness causes soft, non-adhering sludge and permanent or non-carbonate hardness causes hard, adhering scale. Calcium and magnesium are the active ingredients in the formation of scale, which in addition to compounds of these elements contains the suspended matter, silica, iron oxide and alumina from the water. The carbonates of lime and magnesia, hydroxide of magnesia and sulphate and silicate of lime are the main constituents of boiler water deposits. Organic matter, salts of sodium and oil frequently occur also. As a rule one of the above main constituents predominates when deposits are formed.

The important point in a discussion of scale in boilers is not how to get rid of scale but how to get rid of the mineral constituents in the water from which scale is formed.

WATER SOFTENING

Many waters can be much improved for boiler and other uses by softening, which consists in removing calcium and magnesium from the water. By modern methods it is possible to make hard water soft so that it is not necessary to have the inconvenience and unpleasantness which accompany the use of hard water. The removal of lime and magnesium compounds from a water can be accomplished by precipitating them with chemicals or by long exposure to the air or at least to a partial extent even by heating. The chemical methods are preferred.

Two general types of softening systems are in use--the lime soda system, which has been in use for many years, and the base exchange or zeolite system, which is a recent development. The zeolite system has been known for many years, but has not been fully developed until recent years.

Lime-Soda Method of Softening.--"The lime-soda system com-

prises two sets of reactions. Lime is added to the water to take care of the free carbon dioxide and the bicarbonate and an extra quantity corresponding to the magnesium. In general this addition may be said to reverse the process by which the calcium carbonate of the rocks was dissolved by the water. This solution took place by reason of the carbon dioxide in the water. If the right quantity of lime is added it unites with the carbon dioxide, thus releasing the calcium carbonate taken up by the carbon dioxide and at the same time settling out as a precipitate. This much softening is clear gain; the added calcium separates out with that which was in the water. This treatment removes only carbonate hardness.

"To convert noncarbonate to carbonate hardness soda (sodium carbonate) is added to the water. Calcium sulphate is changed to calcium carbonate and the sodium carbonate to sulphate. The calcium carbonate settles out, but sodium sulphate remains in solution. This treatment softens the water but leaves in solution about the same total quantity of mineral matter. Some natural waters contain so much noncarbonate hardness that they can not be treated successfully by this method. After the scale-forming constituents are removed these waters contain such a quantity of sodium salts that they are not fit for boiler use on account of foaming.

"The lime-soda process is carried out either intermittently or continuously and either with cold or hot water." (29)

(29) Howard, C. S., Chemical Character of the Waters of Mississi U. S. Geological Survey Water- Supply Paper 576, p. 25.

Zeolite Method of Softening--- The base exchange or zeolite system of water softening makes use of alkaline aluminum silicate of either natural or artificial orgin. When hard water flows thro a bed of grains of zeolite or exchange silicate, the calcium and magnesium in the water are replaced by sodium, leaving the water practically free from hardness. No chemicals are used in the softening process except common salt which is used to regenerate the mineral or exchange silicate. In the reversed reaction the salt used in regeneration gives back sodium in exchange for calcium and magnesium removed from the water. After washing, the zeolite is ready for use again. This regenerating process can be carried out repeatedly, there being very little waste of the mineral. The hardness is entirely removed and no excess of chemicals is added. This softening process adds nothing to the water, uses no chemicals and needs no pumps. (30)

(30) Bartow, Edward, Water Softening by Base Exchange, Proc. Iowa Acad. Sci. for 1931, Vol. 38, pp. 151-5.

RELATIONS OF CHEMICAL COMPOSITION OF GROUND WATERS TO WATER-BEARING FORMATIONS

It has not been possible to investigate extensively the chemical composition of the ground waters of Indiana. Where analyses have been available they are presented. The analyses of the ground waters and the statements that have been made in regard to the suitability of the waters for domestic use consider only the effects of the dissolved mineral constituents. They do not consider the presence or absence of disease-bearing bacteria, which is usually the determining factor in any consideration of a public supply.

Extreme caution should be exercised in the location of new wells and scrupulous care must be taken to prevent pollution of existing wells and springs. Some of the factors to be considered are natural drainage of the surface, of the buried bedrock when the bedrock is near the surface, the locations of possible sources of pollution and their eradication, and possible sources of contamination from near the well curb.

The Mitchell Plain region of Indiana has some special hazards in regard to underground drainage and water supply. Where solution channels have developed in limestone it is possible for ground water to circulate extensively and to be polluted over wide areas. The sanitary character of all water from springs and wells in the limestone belt should be considered and periodic sanitary analyses made as a precautionary measure. Sterilization of public supplies that issue as ground water from channeled limestone is highly recommended. A great many cities and towns use some type of chlorinating apparatus as a routine precaution. This is to be commended.

A study of the ava ilable analyses of ground waters in Indiana shows no outstanding relation between the chemical character of the ground water and the stratigraphic horizon of the water-bearing beds.

There are several factors which tend to discount and make relatively useless any chemical analyses of ground waters. It is impossible to tell the exact stratigraphic horizon of the water-bearing bed of many wells. This is due to a failure to keep an accurate record of the strata penetrated. The present study has brought out this fact forcefully, and attention has been directed in the introduction to the desirability of keeping and filing accurate water well records. Another factor is the human one. Drillers' memories are not infallible. Water well data are often handed down by word of mouth. This study has shown that rare indeed is the well owner who can give all the essential information concerning his source of water supply. In addition to the failure to remember drilling data, is the further complication that individual judgment enters into the problem. One driller will record a formation as shale, whereas another records the same formation as marl. Well records at best are poor indicators of the geologic column, but over a wide area can be if used with discrimination. Another source of confusion in regard to an interpretation of chemical analyses is that many wells

secure water from more than one stratigraphic horizon. A given sample then would not be representative of any given horizon. Still another source of error is that casing seats give away, casings rust and holes permit the penetration of water from upper horizons. Also when deep wells are drilled in an area, waters of different chemical composition frequently rise in a well and penetrate other water beds higher in the column. In Indiana the present plugging of deep wells seeks to prevent this source of pollution, though a certain amount of pollution is bound to occur.

It is believed that any particular stratigraphic unit may have considerable lateral and vertical variations in the beds that make up the formations. P. B. Stockdale (31) has described

(31) Stockdale, P. B., The Borden (Knobstone) Rocks of Southern Indiana, Publication 98, Dept. of Conservation, State of Indiana, 1931.

described the facies changes of the Borden formation. It is logical to conclude that the ground waters associated with any stratigraphic unit will also show variations in mineral character at different depths and places.

A study of well records and analyses of water from these wells which are known to produce from channeled limestone formations shows that ground water of different chemical character is yielded at different seasons.

It has been observed that the draft on a well often affects the mineral content of the water. Water commonly shows a higher mineral content when a well is new than after it has been used for some time. A case to illustrate this fact is that of the well drilled in the Dunes Park of Indiana located in Porter County, which secured fairly strong sulphur water. This sulphur water occurs in the Devonian limestones of the area and continued pumping of the aquifer caused a freshening of the water until it became potable.

It should be added that frequently excessive pumping may increase the mineral content of the water because of the local lowering of the water table and consequent indraught from other beds. Reference has already been made to this condition in discussing the lowering of the water table due to prolonged drought and the accompanying derangements of old adjustments, with subsequent deleterious effects.

THE LOWERING OF THE WATER TABLE

Well waters of Indiana may be grouped into two classes, as to origin; derived from the glacial drift, with its interbedded sands and gravels, and those obtained from the bedrock. It has been pointed out in the discussion of glacial deposits that the great body of the glacial drift consists of pebbly, compact till which is predominantly clay. This absorbs water slowly and likewise yields it sparingly. The lenses of sand or gravel associated with the glacial drift are excellent reservoirs, and wells which penetrate these beds obtain copious supplies of water, dependent of course on the texture of the beds and their vertical and horizontal extension. The water from bedrock might again be subdivided into water from outcropping strata and strata immediately underlying drift, and water derived from deep wells. With a few local exceptions the deep wells of Indiana do not produce potable waters, therefore, deep sources can be omitted from the discussion.

For many years geologists, engineers, hydrologists, municipal water superintendents, and others interested in the subject of ground water have been of the opinion that in many places the water table is declining. The water table is defined as the upper surface of the zone of saturation in ordinary permeable soil or rock. That there has been such a depletion since settlement of Indiana began is a matter beyond question--the difficulty lies in determining the causes and the amount, as well as the remedy.

W. J. McGee(32) made an investigation of the relations

(32) McGee, W. J., Bulletin 92, Bureau of Soils, United States Dept. of Agriculture.

of wells and subsoil water in 1910, for the U. S. Bureau of Soils. This investigation covered the entire United States. Among other facts it was ascertained that Iowa, Illinois and Indiana were classed as having the most dependable records. McGee attacked the problem in this manner. Five or six reporters were assigned to each county unit. These reporters observed the levels of ground water both from their own experiences and others over a period of years. These data were submitted to McGee who divided the wells upon which reports were made into shallow or dug and deeper or drilled wells, excluding flowing wells and those of great depth. The data were summarized and tabulated. A majority of the observers reported that the general water level had been lowered. McGee stated that for the typical agricultural states, "The average lowering since settlement would appear to be no less than 9 feet, i.e., from well within to about the limit of capillary reach from the surface." Lees(33)

(33) Lees, James H., Well Water Recession in Iowa , Vol. 33, Iowa Geol. Survey, 1927 (1928), pp. 375-400. Also, Journal of the American Water Works Association, Vol. 18, No. 3, Sept. 1927. Address presented before the Chicago Convention, June 9,1927.

has summarized McGee's work as follows:

"Causes of lowering.-- In discussing the causes of the lowering water table McGee dismissed a lessened rainfall as being negligible and unproved. Industrial causes such as tile and open ditch drainage, large wells, mining, etc., are of only local and rather superficial importance, as is consumption by animals and men. The greatest amount of lowering-- amounting to 80 or 90 per cent-- McGee assigns not so much to consumption of accumlated stock as to the cutting off of the natural source of supply -- the fact that under present conditions of cultivation storm waters do not enter the ground, but run off to the streams and so are unable to replenish the stores of ground water. The remedy, McGee points out, is to make each farm take care of all the water falling on it during the entire year by retaining this water by means of mulch or well-tilled soil or contour furrows and ridges so that it will be forced to pass into the ground."

In 1910, Mr. Charles Brossman (34) published the following data

(34) Brossman, Charles, The Public Water Supplies of Indiana, Proc. Ind. Acad. Sci., 1910.

on the water table recession in Indiana.

Towns	Water level
Kentland (old gas well)	48 feet drop in 5 years.
Elwood	40 feet drop in 12 years.
Greensburg	40 feet drop in 10 years.
Muncie	28 feet drop (time not given).
Remington	8 feet drop in 10 years.
Marion	6 feet drop in 20 years.
Butler	4 feet drop in 10 years.
Bourbon	3 feet drop in 8½ years.
Linton	30 feet drop in 6 years.
Kokomo	15 feet drop in 15 years.

The writer has endeavored to bring to date information bearing on the lowering of the water table. He has found a general consensus of opinion that there has been a distinct lowering of the water table, but a consistent lack of definite figures to substantiate this opinion. The causes and the amount of depletion, likewise the remedies to apply are debated subjects.

There are several reasons or explanations for the decline of

the water table. Named in the order of their importance they are: waste of water, surface draining by artificial means, over-devel p-ment of the underground water, and perhaps deforestation. Not all students of this subject would agree with this classification.

Indiana has been favored with an abundance of ground water in most sections. Certain areas have restricted supplies and it is only within the last few years that the necessity for the conservation of ground water has become apparent. Ground water has been permitted to flow away in many counties where oil and gas have been sought. Wells were not plugged or were not plugged properly. Also many open artesian water wells have been permitted to flow copious streams of water for years, even when the water was not in use. Another important source of waste which is being gradually eliminated has occurred in cities where water has been wasted recklessly. The installation of meters in many towns and cities has tended to eliminate this waste.

The effect of surface drainage by ditching and dredging has already been discussed.

The underground water resources of any area can be overdeveloped. Too many wells can be drilled and daily removal of water supplies can exceed the yield of the aquifer. Anderson (35) has cited the case of the City of Chicago as

(35) Anderson, Carl B., The Artesian Waters of Northeastern Illinois, Bulletin No 34, State Geol. Survey of Illinois, 1919, pp. 36-7.

illustrating this condition, quoted as follows:

"The hundreds of deep wells drilled in this area since 1864, have drawn exhaustively upon the underground water resources, causing a recession of the artesian-water thole. The amount and rate of lowering has not been the same everywhere. It is in those localities where many wells of large yield have been drilled that the recession is the most marked. This is particularly noted in Chicago and immediate vicinity. The tabulated data indicate the recession and its rate in the different localities and the length of period over which the measurements extend. In general it will be seen that the recession is most rapid where development is greatest, a striking example being Chicago and vicinity."

In many towns and cities the shallow supplies of water soon become contaminated and are unfit for use. In the Calumet District of the northwestern part of Indiana, it has been necessary to obtain water from a distance out in Lake Michigan. Surface contamination from various industries, city sewage, and general heavy withdrawal of ground supplies made it necessary to resort to lake waters.

Deforestation and its influence on ground water levels have been discussed elsewhere in this report.

UNDERGROUND WATER OF INDIANA IN THE FUTURE

It has been emphasized that precipitation is the chief source of ground water in Indiana. The State is distinctly fortunate in

having a rainfall which is dependable. Weather Bureau records show that the driest years receive considerably more than half as much rainfall as the wettest years, and very rarely is the departure from the normal as much as 25 per cent. In 1929 there was an excess of precipitation of 7.75 inches, much of which occurred during the spring and summer. In 1930 the deficiency was 9.59 inches, and the spring and the summer as well as most of the remaining months of the year were very dry. From March 1, 1930 to Jan. 31, 1931 the accumlated defiency in precipitation for the State was 15.18 inches. Between Jan. 1, 1931 and Dec. 31, 1931 the accumulated deficiency for the State for that particular year amounted to 1.15 inches. The years of 1930-31 will be long remembered in Indiana for the drought. In no year during the sixty years of official record at Indianapolis, has as little as 30 inches of rainfall been received, although the average is only slightly more than 40 inches. While it is true that locally water supplies were exhausted during the drought of 1930-31, that condition was only temporary. It is concluded that precipitation in Indiana has always been adequate to supply an abundance of ground water. It is believed that rain will always continue to fall in sufficient quantities to replenish aquifers.

A survey of wells which have been abandoned in the State because it was assumed that the aquifer had been exhausted of its potential water supplies shows that in many instances erroneous conclusions were drawn. In many localities when additional water was required, new wells were bored into the same aquifer, but the wells were entirely too close together. The result was that the wells were sympathetic and the supply was divided, usually causing a lowering of the old well and no increased flow from the new well. The history of the development of wells indicates that some degree of systematic spacing of wells is necessary. It is true that the water table has been lowered in restricted areas by excessive draining of the aquifer. The city of Chicago, and also the city of Ft. Wayne have had this experience. Thwaites (36) Sug-

(36) Thwaites, F. T., Stratigraphy and Geologic Structure of Northern Illinois, State Geol. Survey, Report of Investigations No. 13, 1927, p.47.

gested that in the case of depleted aquifers, the reduction of water pressure had probably resulted in settling and compacting of the sandstones so that the porosity of the rocks has been permanently lessened.

Another very important source of water supply restriction is based on the condition of wells and their equipment. Very frequently mechanical defects develop in pumping equipment, in casing in the casing seat and in sanding up of equipment. Many wells are of small diameter. It has been observed in many Indiana localities that whereas wells of small diameter are inadequate, wells of large diameter and of special type construction give an abundance of water. The use of the gravel-wall well has become more common throughout the State. Its use where sand has been a source of constant trouble has been especially successful.

Throughout northern Indiana, or all of the State which has been glaciated, drilled wells frequently end in sand belonging to the glacial drift. The finishing of these wells is perhaps the most important problem in connection with water supplies. The sand rises with the water so persistently that it is necessary to put a screen or strainer at the bottom of the casing to shut out the sand while admitting the water. Various types of screen are in use, but the common type for wells of small diameter consists of a perforated iron pipe surrounded by a brass gauze of fine mesh, the whole inclosed in a perforated jacket to protect the gauze. The screen, of course, must be small enough to fit inside the casing. It has been observed that wells finished in this manner yield for a few years, but finally the yield decreases and eventually diminishes to practically nothing. When the screens are removed they are found to be coated with an accumulation of silt, etc., which has become firmly cemented into a hard incrustation. While it is true that a new screen will replace the old one, it is often necessary to pull the casing in order to remove the screen and its load. When the casing is removed, caving often results and irreparable damage is done to the hole. Many well owners prefer to abandon the old well and sink a new one, especially in localities where shallow water is utilized. Frequently work-over jobs are costly and exceed in expense the drilling of a new well. If the original well is deep the forming of an incrustation on the screen is a serious matter.

Meinzer(37) has described a typical occurrence of incrustation of a screen from a well in Martin County, Minnesota. The main cementing substance was calcium carbonate precipitated from the water, and sand, silt and clay were packed about the screen by the inflow of water so that the whole became an impervious sheath which effectually shut out water. The work and study of incrustation were summarized as follows:

(37) Meinzer, O. E. Finishing Wells in Sand. Vol. 21, Iowa Geol. Survey, Underground Water Resources of Iowa, by Norton, Hendrixson, Simpson, Meinzer, et al., 1912, pp. 219-26.

"Only wells of large diameter (four inches or more) should be drilled. Care should be taken to drive the casing through the cap of "hardpan" and through any beds of quicksand which may exist to the coarsest portion of the deposit. The fine sand should then be removed by protracted pumping and a natural screen of coarser sand or gravel developed. Gravel of the proper coarseness may also be introduced into the well to be added to the natural strainer. If the water is to be drawn at a slow rate and an independent pump is used, it is generally not necessary to put on a metal screen. If, however, the water will not become clear and the sand persists in rising, a screen should be inserted and tightly attached to the bottom of the casing. It should

be considerably smaller than the latter so that it can be easily removed when it has become incrusted. As soon as the yield of the well shows distinct signs of reduction, the screen should be drawn up and cleaned or else replaced by a new one."

It is concluded that in Indiana there is a limit to any locality's withdrawal of ground water. Several factors have an influence on that limit, but public supplies must be obtained elsewhere than from the ground when the balance between that amount of water in the aquifer and the replenishment sources is seriously disturbed. Indianapolis, Fort Wayne and Evansville depend upon river waters; Indianapolis in part on ground water. South Bend is still using well water. The location of cities with respect to available lake or river supplies is a vital factor in making a choice between river and ground water. Where practical it is suggested that industries that do not require pure water be encouraged to develop surface waters.

The smaller cities and towns in Indiana will always be supplied by ground water, though care must be exercised in regard to pollution. In the section of this report devoted to geology, certain regions are pointed out which are deficient in ground water and will always be deficient. Provisions for surface waters must be made in these areas.

Deep water wells in Indiana have not been successful. They usually contain salt or sulphur waters unfit for use. It is to be expected that in northwestern Indiana some of the deep aquifers would yield potable waters. Similar horizons in Illinois produce good water. Fresh waters have been reported from below 1200 feet in wells in Pike County, believed to be in the Mansfield sandstone. Usually the Mississippian and Pennsylvanian deep horizons in southwestern Indiana yield waters unfit for use. In eastern Indiana salt water is invariably encountered in the Trenton formations. In central Indiana along the strike of the Mississippian formations, deep wells yield mineralized waters. On the whole the outlook for deep waters which are potable is unpromising for the State of Indiana. Our information is based on some fifteen deep wells drilled in this State. Two or three of these wells reported fresh water at considerable depth. Chicago has many deep wells which obtain fresh water, so perhaps northwestern Indiana might utilize the same horizons. It is possible that the supply would be exhausted due to heavy withdrawals in the city of Chicago so that northwestern Indiana could not obtain a sufficient supply from individual wells. Also deep wells are expensive and individuals cannot afford to drill them.

The wells drilled into strata just below the drift are usually excellent and this horizon will continue to be a producer. The drift is the source of this supply, plus the fact that strata underlying the drift are porous. Certain areas underlain by drift are not aquifers owing to textural conditions of the strata.

The glacial drift and river alluvial deposits will continue to supply Indians with water. Locally the supplies may diminish, but investigation usually shows sufficient cause. It is recommended that competent hydrologists be engaged to study water systems which are suspected of depletion of supplies. Frequently larger wells and modern work-over jobs make excellent producers from old locations. The water problem is peculiar to each community, and must be solved after a study of the local conditions. No panacea are suggested for failing supplies and this study is intended to indicate the general facts of the ground water situation of the State with an added suggestion that conservation of ground water is imperative.

GEOLOGIC STRUCTURE

MAJOR STRUCTURES

The major feature of the geologic structure of Indiana is the northwestern extension of the Cincinnati Arch, a geanticline, which enters Indiana near the southeastern corner of the State. The axis of the arch extends from East of Cincinnati to Muncie, Marion and Wabash.

Another geanticline enters Indiana from the northwest in the general vicinity of the present Kankakee River. This is known as the Kankakee Arch. It is a relatively small uplift trending north 45 degrees west and is believed to be related to the Wisconsin Arch in age. The Wisconsin Arch is a broad fold with an axis trending north 20 degrees west, extending from central Wisconsin southeastward into Illinois. Pirtle (38) has described the Wisconsin Arch as a fold following a line of

(38) Pirtle, George W., Michigan Structural Basin and its Relationship to Surrounding Areas, Bulletin American Assoc. of Petroleum Geologists, Vol. 16, 1932, pp. 145-52.

deformation of the pre-Cambrian mountains. The Kankakee Arch of Indiana probably marks the southeastward continuation of the pre-Cambrian deformation. It has been further suggested by Pirtle that this line of deformation may be responsible for the Indiana branch of the Cincinnati Arch, and that the Kankakee Arch antedates the Cincinnati Arch of Indiana.

In the vicinity of Logansport occurs a synclinal area, often referred to as a structural sag.

These major structural features have been determined from a study of well records, both in Indiana and in other adjacent States. With the exception of eastward and westward dips from the crest of the Cincinnati Arch, there is little surface evidence of these immense structural features. The Cincinnati Arch is from 20 to 40 miles across the top and the strata are fairly flat at this horizon. Logan (39) has published structural

(39) Logan, W. N., The Sub-Surface Strata of Indiana, Publication No. 108, Dept. of Conservation, State of Indiana, 1931, pp.18-23; Handbook of Indiana Geology, Part V, Publication No. 21, Dept. of Conservation, State of Indiana, 1922, pp. 837-42; Some Features of the Upper Surface of the Trenton Limestone of Indiana, Proc. Ind. Acad. Sci., Vol. 38, 1928, (1929) pp.225-30.

maps and data pertaining to the subsurface conditions of Indiana. A structural map based on the upper surface of the Trenton formations as a datum plane accompanies this report and shows the major structural features of the State. This is Plate No. IV.

From east of Cincinnati, Ohio, to Marion, Indiana, the upper surface of the Trenton formations is approximately 100 feet or slightly higher above sea level. Strata dip to the southwest and to the northeast from this axis or crest of the geanticline. As the geanticline continues northwestward, the upper surface of the Trenton becomes lower and lower. At Peru, the same surface is about 200 feet below sea level. Near Logansport, the upper Trenton surface is approximately 300 feet below sea level. This structural map indicates that the Cincinnati Arch is a great plunging geanticline. On the crest of the geanticline the dips are small, though on the flanks the dips increase toward the great basins on the East and West.

The Kankakee geanticline plunges southeastward. It is probable that deep aquifers bring ground waters into Indiana. The aquifers are controlled by the structural conditions of the Kankakee Arch. In adjacent portions of Illinois some of the deep strata are excellent producers of water, so that it is likely that some of these water-bearing formations should yield potable water in northwestern Indiana.

In addition to the positive structural features, Indiana is underlain by portions of certain structural features of the basin type. A great geologic basin is centered west and southwest of Princeton in Gibson County, and extends into Illinois. This is the great Interior Coal Basin and is a very pronounced structural feature. Strata dip toward this basin from the crest of the Cincinnati Arch and from the crest of the Kankakee Arch. The strata are also known to thicken basinward. Many of the oil and gas fields of southwestern Indiana are located on minor structural irregularities of the monoclinal slope into the basin.

Another great basin is located near the middle of the southern peninsula of Michigan. The bedrock of Indiana located north and northeast of the Kankakee Arch and the Cincinnati Arch dips toward this Michigan structural and sedimentary basin. This Michigan basin probably originated in pre-Cambrian time. From the bottom of the basin southward there is a rise of 6000 feet to the same stratigraphic position on the Cincinnati Arch in Indiana.

It is quite probable that many of the formations younger than those which are now found on the Cincinnati Arch were deposited over the arch. The Indiana portion of the Cincinnati Arch originated in late Ordovician time. From this time on the arch remained near sea level, but at times was submerged. The greatest outcrop of Silurian strata is across the crest of the Cincinnati Arch. Also the Mississippian sediments are fairly thick on the southwest side of the arch, which suggests that the main deformation came after the deposition of the Mississippian formations. In Indiana the rocks found on the crest of the Cincinnati and Kankakee arches are largely of Ordovician and Silurian age. Southwestward the Devonian, Mississippian and Pennsylvanian strata occur on the flanks of the geanticline. The

same succession is found northeast of the geanticlines, though the Pennsylvanian is not known to be present in Indiana northeast of the structures.

SECONDARY STRUCTURES

There exist many minor structural features in the State. The anticlines, synclines, and faults are the chief irregularities of this type.

The many oil fields in widely scattered localities of Indiana are located on some of these structural irregularities. The older Trenton fields of the State, the Devonian limestone production, the Pennsylvanian and Mississippian production are associated with minor structural features. These are positive features on a smaller scale and other types of structure are associated with them.

Many faults have been mapped in Indiana. Some are of little throw and others show considerable displacement. Oil and gas frequently occur in connection with faults. The proper geologic conditions for the accumulation of oil also serve to trap water. The ultimate effect may be to stop circulation of ground water, and cause stagnation; or in many instances the reverse effect is noted. The faults frequently serve as avenues of escape for entombed waters.

An interesting case of relation of faulting to ground water is that of the Unionville gas field of Monroe County. Fresh water is reported from the Devonian limestone. Ordinarily at this horizon sulphur or salt water is reported, especially down the dip and at depth. In the Unionville field the fault has apparently effectually sealed off the brackish waters and on the southwestern side of the fault, the Devonian strata bear fresh water. The Trenton formations in this same field yield salt water.

STRATIGRAPHY

SEQUENCE AND GENERAL CHARACTER OF THE ROCKS

The rocks of Indiana include both unconsolidated and onsolidated sedimentary rocks, but no igneous rocks native to he State are known. Certain igneous and metamorphic boulders ere brought into the State by the Pleistocene glaciers, but hese rocks are not indigenous to Indiana.

The unconsolidated rocks are stream-terrace, stream-bed, alley flat or flood-plain deposits, glacial till, glacial oraines, outwash plains, lacustrine plains, dune sands, and esidual deposits. These are of Quaternary age, belonging to he Pleistocene and Recent. In addition certain small areas of ands and gravels on uplands adjacent to the major valleys and in laces capping certain high hills in southern Indiana, belong with he unconsolidated deposits. Part of these gravels and sands are egarded as equivalent to the Lafayette formation of late liocene age and others are believed to be older. In northwestern ndiana occur considerable areas covered with dune sands. Also imilar sands are found in the valley of the Wabash River, south- ard from Terre Haute and east of White River, south of the isconsin drift margin.

When it is recalled that approximately five-sixths of the urface area of Indiana has been glaciated, and that the non- laciated middle-southern portion of the State is crossed by everal major streams, notably the East Fork of White River, atoka River, Blue River, Anderson River, and several minor treams, each having relatively wide floors of alluvium, and the resence of lacustrine deposits in old glacial boundary lakes nd certain Pleistocene terrace deposits, the relative importance f the unconsolidated deposits of the State is quite evident.

The consolidated sedimentary rocks range in age from rdovician to Pennsylvanian. These are the strata which are ex- osed. Wells drilled to great depths have gone through rocks etermined by well cuttings to be still older. The consolidated edimentaries consist of various shales, limestones, dolomites, herty limestones, sandstones, siltstones, coals and underclays.

The consolidated sedimentary rock sequence is broken, in any places, by many minor disconformities and by several major isconformities. In certain areas parts of the geologic column re missing entirely. By a careful examination of the records nd cuttings of well borings, and by a comparison of these with he geologic succession in other areas where the deep-lying beds f Indiana outcrop at the surface, geologists have been able to etermine, in some detail the sequence of rocks which lies below he surface at great depths.

In general the occurrence of ground water in any region depends in some measure upon the texture and porosity of the rock In this way stratigraphy, is a guide to the development of ground water supplies. From a lithological study it is oft times impossible to identify certain horizons a few miles away, so recour is had to the contained fossils. Certain stratigraphic units do not have distinguishing lithologic characteristics and facies changes are recognized from area to area.

The structural conditions of the strata, their attitude, dip, depth, nearness to surface, outcrop area, porosity, possible fracture and jointing features, elevation, and permeability are some factors to be considered when studying the relationship between ground water and stratigraphy. It is frequently difficult to apply in practice all the criteria used to ascertain the productiveness of any given horizon for a water supply.

The stratigraphic sequence as at present recognized in Indiana is given in the following detailed descriptions of the stratigraphy. The general lithologic characters of the rocks, their known character as purveyors of ground water, and summary of important facts concerning each unit is included in the discussion to follow.

The sequence of description in this report is the inverse of that which is usually followed in geologic reports, in that the formations are described from the top of the geologic column downward, which is the order in which the strata are penetrated in well borings.

QUATERNARY SYSTEM

The water-bearing beds of the Quaternary system are numerous and their positions are extremely variable. The Pleistocene deposits of glacial and fluvio-glacial origin and the Recent deposits make up the Quaternary.

The Recent water-bearing beds, more frequently recognized and reported, are the alluvial deposits along streams and the sands of aeolian origin or at least shaped into dunes by the wind similar to those along the Indiana shores of Lake Michigan. The master streams of the State and the lower courses of their larger tributaries are bordered by flood plains. These flood plains are composed of silt, sand, and gravel and detritus weathered out from formations over which the waters have flowed.

The alluvial flood plains are subject to overflow at times of high waters, so that they are unsuited for town or individual development. Nevertheless, many homes are located in these low areas and must depend on the flood plain deposits for water supplies. The Ohio River has developed a series of terraces in the course of its history. A few towns in Indiana are located on the terraces and depend on wells drilled into these gravel terraces to supply water.

A large portion of the water in alluvial deposits is absorbed directly from rainfall, for the porous beds will readily receive large amounts of water. Also the seepage received from adjacent uplands is very important and supplies most of the flood plain deposits.

In the case of water-bearing beds in flood plain areas, the water movement underground is the same as that of the surface water, from the uplands toward the streams. In most cases the banks of a stream supply water to the stream rather than being fed by the stream. In arid regions, and in limestone cavern areas this latter condition may prevail and under exceptional conditions in the State such might be the case. Chemical analyses of the stream waters and of the ground waters of the bottom lands usually show a great difference, the stream water containing much less lime than the ground water. At stages of high water and under heavy pumping movement toward the land from the stream may occur, as the tests made by Kiersted (40) at Muscatine, Iowa, illustrate.

(40) Norton, W. H., Underground Water Resources of Iowa, Iowa Geol. Survey, Vol. XXI, 1910-11, pp. 563-66.

For 3300 feet from the river there was found a slope of the ground water surface toward the river of 0.8 foot in 1000 feet and a rate of flow in this direction of at least two and one-half feet per day. But with the rise of the Mississippi, the normal flow of ground water was first dammed and then reversed, reaching a slope inland of 0.84 foot in 1000 feet, and flow from the river at about the rate just mentioned.

In the open and more porous beds of valley alluvium the movement of the ground waters is relatively rapid. The water table of the uplands is higher than that of the valleys, and this causes the water to move streamward. There is also some movement of the waters down the valley. Under favorable conditions artesian pressure may develop in alluvial deposits, the head being furnished by the higher water table of the uplands.

The sandy areas in northwestern Indiana are indirectly associated with glaciation inasmuch as they originated as sandy lacustrine deposits and were later blown about by the winds. The Maumee Lacustrine Plain in Allen County, the Kankakee Lacustrine Plain, which is the basin of the present Kankakee River, and the Calumet Lacustrine Plain, along the Calumet rivers are areas formerly occupied by large lakes. The present basins are sandy plains whose surfaces have been modified by wind, man, and other agencies since the retreat of the ice sheet. Large areas in these old lake basins were marsh land and unfit for use, however, dredging and tiling have reclaimed many acres of the land.

In the sand dune area of northwestern Indiana, the sand is heaped into dunes by wind action. Any water contained in these dunes must come from the rainfall. The individual sand grains pack closely and the pore space is smaller than in the ordinary sandy lake deposit. The dune areas are covered with fairly shallow deposits of sand and the water soon drains from them.

The sandy deposits east of the Wabash and White River south of the Wisconsin glacial margin are locally of importance as water horizons. In many places these sandy deposits become quite thick.

RECENT ALLUVIUM

Alluvium comprises stream deposits, such as the gravel, sand, silt, and clay usually composing the floors of valleys. Everywhere in Indiana it is present in greater or less quantities in all valleys except a few whose streams flow on bedrock or which are located so that they have very steep gradients. All the larger streams of the State have broadened their valleys and built up flood plains along at least part of their course. Many of the smaller streams have patches of alluvial bottom land along their valleys. The deposits are composed of the roughly assorted detrital materials which the stream has carried and left in favorable localities. The materials are gravels, sands, and silts, derived from the glacial deposits and from any material over which the streams have traveled, and contain the native bedrock fragments of limestone, shale and decomposed sandstones as well as the glacier-borne erratics. Superficially the alluvium generally consists of a sandy silt, but sand or gravel is usually found not far from the surface and continues to the bottom of the deposit, except for a few more clayey beds at intervals. According to the statements of drillers, sand predominates in most wells, the gravels being rather fine and in beds of no great thickness. It is true that many driven wells are employed in alluvial deposits and no evidence is derived from them concerning the character of the deposits.

The alluvial flood plains range in thickness from a very thin mantle to 150 or more feet in the larger valleys of southwestern Indiana. The flood plains are subject to overflow at high stages of the streams, and so are not adapted for town sites or for sites for industrial development. Private water supplies are frequently secured from these areas. Where the flood plains can be protected from overflow these areas are potential sources for water supplies.

ALLUVIAL TERRACES

Terrace alluvium differs from the common stream alluvium in being the result of past rather than present stream action. Alluvial terraces stand distinctly above the level of the existing flood plains. In general, the terrace materials are somewhat coarser than the alluvium, with gravels predominating. Sand and clay layers occur with the gravels in sufficient quantities to act as a binder, for locally the terraces become consolidated.

Alluvial terraces are characteristic of all streams in Indiana which discharge glacial waters south or southwesterly from the Pleistocene ice sheets. Commonly terraces are present in tributary streams also, but these are frequently composed of clay rather than gravels and sands. The alluvial terraces, therefore, are Pleistocene in age.

The terrace deposits are rather thoroughly drained and are of small areal extent. They are not a potential source of large quantities of ground water, though several Ohio River towns located on these terraces obtain water supplies from them. Local supplies at Vevay, which is on such a terrace are obtained from this formation, though the main city supply is procured from the Ohio River.

GLACIAL DEPOSITS

The glacial drift of Indiana includes the deposits of two or more glacial stages, the Wisconsin and at least one stage of pre-Wisconsin age. The earlier till sheet is usually assigned to the Illinoian. Each drift sheet consists of two classes of material, the stony clay or till, which was laid down directly by the ice, and the assorted beds of silt, sand, and gravel, which were laid down by contemporaneous waters.

The Wisconsin drift sheet did not extend as far south as did the Illinoian, so that there are many areas south of a line from Terre Haute to Brookville where just one drift sheet is represented. The Illinoian glacial lobe was first outlined by Leverett (41) in 1899, and with some slight modifications as to

41) Leverett, Frank, The Illinois Glacial Lobe, U. S. Geol. Survey, Monograph 38, 1899.

boundary locations has remained about as originally outlined. North of the Terre Haute-Brookville line, which is the southernmost extension of the Wisconsin drift sheet, the Wisconsin till overlies the Illinoian, and is largely responsible for the present topography.

EFFECT OF GLACIATION ON TOPOGRAPHY

It is interesting to speculate on the physiography of Indiana before the great glacial invasions. A triangular area in middle-southern Indiana comprising about 6000 square miles is driftless, and this area is a fair example of Indiana physiography which has remained unglaciated. It must be added that all the agencies of erosion have been active on this area for untold ages, preceding the actual date of the first glacial invasion, and also, during and since the glacial invasions.

Before the great invasion of ice, the topography of five-sixths of Indiana was very different from that of the present. As the underlying rock formations of the glaciated area have their equivalents represented in surface rocks in the driftless area, we can have a fair idea of the effects of erosion and weathering on these formations. Preglacial streams carved out valleys, areas of resistant strata were lowered less than areas of weaker rocks, and special forms were created by differential weathering and erosion. Most of these earlier stream valleys had courses very different from those followed by the present streams and the surface of the country was more rugged than it is now. Cumings and Shrock (42) have described some of the ancient reefs

(42) Cumings, E. R. and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Dept. of Conservation, State of Indiana, 1928, pp. 138-64.

which were formed in Silurian (Niagaran) seas and which at the opening of the Pleistocene stood up as isolated and conspicuous hills. The Pleistocene glaciers buried all these under the drift.

Deep well data show numerous pre-glacial valleys which were cut below the adjacent bedrock uplands. These valleys, as well as the uplands, are usually completely buried by the glacial drift and we do not know much about them. Dr. C. A. Malott (43) has listed all the available information on these old valleys. Shrock (44) has called attention and described some of the

(43) Malott, C. A., Physiography of Indiana, Part II, Handbook of Indiana Geology, Publication No. 21, Dept. of Conservation, State of Indiana, 1922 p. 142.

(44) Shrock, R. R., Some Interesting Physiographic Features of the Upper Wabash Drainage Basin in Indiana, Proc. Ind. Acad. Sci., Vol. 37, 1927 (1928) pp. 125-39

physiographic features associated with the Upper Wabash drainage system. The present Wabash River came into existence near the close of the Pleistocene. The Wabash, Salamonie, Mississinewa, Eel, and Little rivers are superimposed streams which have cut through or deeply in glacial drift.

The planation effect of the continental glaciers was supposedly very pronounced. Capps (45) has described the movement of the ice as follows:

(45) Capps, S. R., Underground Waters of North-Central Indiana, U. S. Geol. Survey Water-Supply Paper 254, 1910. p. 26.

"The ice, moving slowly south, first removed all the soil and loose materials, and then, with its base shod with fragments of rock frozen into the ice, gradually wore down the hills and smoothed off the most prominent irregularities. Great quantities of rock debris were picked up and carried by this ice sheet. Much of this material was collected from areas far to the north, from which the ice came, and many boulders of crystalline rock are scattered over the surface and incorporated with the boulder clay. As there are no crystalline rocks in place for a long distance north of the present position of some of these boulders, it is certain that they must have been carried far before they were dropped by the ice."

While it is true that the continental glaciers exerted a pronounced erosional effects upon the glaciated area of Indiana, the depositional effect were far more conspicuous and emphatic in character. Especially is this fact important when the physiography of Indiana is considered. Five-sixths of the surface of the entire State has been modified by glacial action. The topographic conditions of localized areas are due to the action of the depositional effects of the glaciers, plus post-glacial erosion and weathering agencies acting upon them. A study of the glacial map accompanying this report, Plate No. III, reveals something of the import of depositional effects. Terminal moraines, outwash plains, eskers, kames, ground moraine, lakes and the locations of temporary lakes bear witness to the effects of glacial deposition. Even a cursory examination of the glaciated areas shows a topography modified by deposition, whereas little direct evidences of glacial planation are visible.

WISCONSIN DRIFT

GENERAL CHARACTERISTICS AND DISTRIBUTION

The last great ice sheet which covered approximately 23,000 square miles in Indiana has left an imprint which has persisted to the present. The materials left by this ice sheet appear fairly fresh and this alone is an indication of the geological recency of the last ice invasion. Chamberlin (46) named and defined the Wisconsin glacial stage.

(46) Chamberlin, T. C., Classification of American Glacial Deposits, Journal of Geology, Vol. III, pp. 270-7; Vol. IV. pp. 272-6, 1896.

The limits of the Wisconsin drift were traced by Frank Leverett (47). However, Dr. C. A. Malott (48) has given a review of the

(47) Leverett, Frank and Taylor, Frank B., The Pleistocene of Indiana and Michigan and the History of the Great Lakes, Monograph 53, U. S. Geol. Survey, Plate VI.

(48) Malott, C. A., The Glacial Boundary in Indiana, Proc. Ind. Acad. Sci., Vol. 35, 1925, pp. 93-107.

glacial boundary problem in more recent years. To bring this particular question to date, the reader is referred to an articl by W. D. Thornbury, (49) in which some further evidence on the

(49) Thornbury, W. D. Notes on the Glacial Boundary in Southern Indiana, Proc. Ind. Acad. Sci., Vol. 41, 1931 (1932), pp. 351-4

position of the Illinoian glacial boundary in southern Indiana is presented. It is thought best to treat of the boundary of th Illinoian glaciation along with the Wisconsin boundary limitatio

For the distribution of the Wisconsin drift reference shoul be made to Plate III, accompanying this report. All of northern Indiana south to Vigo, and parts of Parke, Putnam, Morgan, Johnson, Bartholomew, Decatur, and Franklin counties are covered with Wisconsin drift. This area is a great glacial plain composed mostly of ground and terminal moraine areas, though als large areas of lacustrine origin are present. The exact thickne of the Wisconsin drift sheet varies from place to place and is largely determined by the character of the surface over which th ice rode. The ice sheet tended to iron out irregularities and t fill in valleys and depressions with transported debris. It is believed that the Wisconsin drift is fairly thick and that heavier deposits of till were made than during the preceding glacial stage. The southernmost Wisconsin drift border is difficult to detect in the field and Leverett (50) points out th

(50) Leverett . Frank, The Glacial Deposits of Indiana--Studies in Indiana Geography, edited by C. R. Dryer, Inland Publishing Co., Terre Haute, Indiana, 1908, p. 37

the boundary occurs at the contact between the loess which mantles the Illinoian drift and the bouldery clay of the Wisconsi drift. In certain areas a well defined ridge is found at the border of the Wisconsin drift. An outer terminal moraine, however does not definitely characterize the entire boundary line distanc

MORAINES

The Wisconsin drift is characterized by the presence of terminal moraines which were formed where the continental ice sheet stood for considerable periods before retreating through melting. The terminal moraine is a thick accumulation of debris made at the end of a glacier or at the edge of the ice sheet, especially where its end or edge has remained stationary for a

considerable time. The ridges of drift are irregular in shape and due to advances and retreats of the ice sheet are usually patchy, as an earlier made terminal moraine is destroyed or converted into ground moraine when the ice sheet readvances.

The morainic masses of the Wisconsin glacial stage consist of a definite system, expressed in a series of more or less concentric terminal moraines deposited in succession as the edge of the ice sheet retreated farther and farther northward. Leverett has studied and published facts pertaining to the lobation of the ice in Indiana. This information is largely contained in Monographs 38, 41, and 53 of the United States Geological Survey. Plate III of this report shows the distribution and classification of the moraines, together with other information of a glacial nature.

The moraines consist of a heterogeneous mixture of glacial debris, composed of gigantic boulders, little boulders, pebbles, and blocks of rock mixed indiscriminately with sands and clays. The boulders and rock fragments are from country rock native to Indiana and from sources far removed from the State. Some of the boulders are crystalline igneous and metamorphic rocks found no closer to Indiana than Canada. Interbedded with the unassorted drift are many lenses or pockets of more or less stratified sands and gravels. These lenses of sand and gravel are the chief water horizons of the terminal moraines. Their appearances in the moraines is uncertain and unsystematic, so that chance guides the destiny of any water well whose set mission is to secure water in these lenses. The contact between the piled-up terminal moraines and the underlying ground moraine is an excellent water horizon and where deposition of the sands and gravels has occurred on top of the ground moraine good water is usually found.

As the terminal moraines are deposited along the front of the ice sheet it is natural to expect them to be hummocky and ridge-like in topographic expression. Many of the depressions contain lakes or have been silted up to form meadows and marshes. Springs often are found at the bases of some of the terminal moraines, many of the springs being only seeps and of intermittent character. The terminal moraines are higher than their surroundings and their only source of ground water comes from the precipation, a large part of which absorbs into the drift. Some of the water which enters the surface of the moraine penetrates into the underlying till. The portions of the moraines which consist of boulder clay contain but little water and give that up slowly. The coarse gravels and sands are more common in the morainal drift, and, as a result, wells are more readily obtained. Dug, drilled, and driven wells are found in the morainal belts.

GLACIAL TILL

All the drift deposited beneath the advancing glacier and all deposited from the base of the ice during its dissolution constitutes the ground moraine. The thickness of the ground moraine is notably unequal. It consists of a compact clayey matrix through which are scattered pebbles, boulders and country rock. The latter range in size from cobbles to immense angular blocks of limestone and dolomite. The clayey drift differs greatly in degree of induration at different horizons, and the contained sand and gravel also become irregularly cemented at certain horizons. Indurated till is referred to as hard-pan by many drillers. The induration of the clay or till is largely the result of secondary changes produced slowly, and may be an index of age. The Wisconsin drift is generally a soft, sticky clay and well drillers report easy digging through it. Below this drift is found an indurated till which is more difficult to penetrate with the drill. This lower till is believed to represent a glacial stage earlier than the Wisconsin, probably the Illinoian stage. Some well drillers have recorded a soil zone between the two tills, showing that in all probability an interval separated them. The buried soils have been reported from the northern part of the State.

Also drillers have noticed an induration of the drift just above the water table. This induration is probably due to the action of ground water. The area acted upon is mineralized highly with calcium carbonate or bog-iron ore.

Another induration reported by drillers is found just above the water bed which yields the flow, especially is this true in flowing well districts. This cemented crust is only an inch or so in thickness and is apparently due to contact with water. This too appears to be a carbonate of lime or iron deposit.

Wells drilled into the till often find the clays and fine sands so compact or so close textured that they will not furnish water fast enough to supply the wells. In most cases deeper drilling will find a looser textured bed, though in some localities such beds do not exist. In the latter case efforts must be made to increase the flow by using special methods of completing the well, however, even then many till wells furnish only sufficient water for small families and a limited amount of stock water. In many localities where the till is so very fine and clayey that water is given up in insufficient quantities, the well must be carried to bed rock or into bed rock. The contact between the till an bed rock is very frequently an excellent water horizon. It is not to be construed that ground water will be found in all wells at the contact between the drift and the bed rock, for in many areas the bed rock in its upper is practically dry.

OUTWASH DEPOSITS

Where an ice sheet ends in a broad face, as did the ancient Wisconsin and Illinoian glaciers, numerous streams flow from it and spread their debris in front of the terminal moraines, forming a broad fringing sheet or outwash plain. Where streams of considerable size form tunnels under or in the ice, the channels fill with debris and in this manner eskers are formed. The outwash plains are alluvial fans or aprons composed of imperfectly assorted gravel, sand and silt. There is a certain degree of sorting as water is the transporting medium, though the moraines and ice margins furnish the sediments in irregular fashion. It is to be expected that the deposited sediments would be coarser at the source and grade outward to finer and finer types.

Another type of outwash deposit is the valley train, consisting of sediments deposited along a pre-glacial valley away from the ice front. The Whitewater valley gravels of southeastern Indiana are a type of the valley train formed by outwash from the Wisconsin ice sheet.

The outwash plains are closely related to the moraines next to which they occur, though such plains are not found adjacent to every moraine. Conditions were necessary which would cause the glacial waters to flow out over a flat plain. One outwash plain frequently mentioned is found in northwestern Kosciusko County and eastern Marshall County. The outwash plain southeast of the Valparaiso Moraine is perhaps the most extensive and most noted within the State.

The outwash plains receive much of their water directly from precipitation and from the adjacent moraines by seepage and regular flow of ground water. In the coarser deposits of the outwash plains, a greater portion of the ground water is available for well supplies. Most of the outwash plains in Indiana are associated with the Wisconsin drift sheet, since the Illinoian glacier left no large terminal moraines. The outwash materials are not indurated. These uncemented gravels and sands are usually good aquifers, unless post-glacial drainage has developed so as to permit the ground water to escape. Many of the wells used in outwash plain areas are relatively shallow and are dug by hand. Sometimes it is necessary to drive or drill wells and if an impervious layer overlies the water-bearing stratum artesian wells result, though many of the gravel wells flow when fed from higher horizons.

ILLINOIAN DRIFT

GENERAL CHARACTERISTICS AND DISTRIBUTION

The Illinoian ice sheet is the oldest recognized glacial invasion in Indiana. There is a possibility that the two or at least one of the two previous invasions came into the State, but at present little information is available concerning pre-Illinoian drift. The Nebraskan and Kansan drifts are represented in other states. Leverett(51) has discussed the glacial succussion in Indiana. At present only the Illinoian and Wisconsin are recognized.

(51)Leverett, Frank, Glacial Formations of the Erie and Ohio Basins, Monograph 41, U. S. Geol. Survey, 1902.

Leverett, Frank and Taylor, Frank B., The Pleistocene of Indiana and Michigan and the History of the Great Lakes, Monograph 53, U. S. Geol. Survey, 1915.

The Illinoian drift sheet covered all of Indiana with the exception of about 6000 square miles in the middle-southern part of the State. This unglaciated portion is frequently referred to as the driftless area in contradistinction to the greater drift-covered portion of the State. The glacial map, Plate III accompanying this report shows the limits of the drift.

The configuration of the borders of the Illinoian drift sheet suggests that a great lobe of the glacier extended west of the driftless area into southwestern Indiana and another lobe went into southeastern Indiana, east of the driftless area. Leverett(52) has described in some detail the effects of the Illinoian glaciation.

(52)Leverett, Frank, The Illinois Glacial Lobe, Monograph 38, U. S. Geol. Survey, 1899.

Because of the heavy cover of Wisconsin drift which mantles the Illinoian drift, only the western-southern and eastern-southern portions of the State show the Illinoian. This mantle of drift is about 30 feet in thickness on the average, though in many areas is much less. Leverett has estimated the average thickness of glacial drift in Indiana(53) to be 130 feet. There are some stream gorges, railway cuts and road fills near the southern border of the Wisconsin drift which show the contact between the two till sheets.

(53) Leverett, Frank, Wells of Northern Indiana, Water-Supply Paper 21, U. S. Geol. Survey, 1899, p. 10.

The Illinoian ice sheet passed over a topography similar to that which exists in the driftless area of the southern part of the State today. Owing to the time element involved, more modification of Illinoian drift would be expected than Wisconsin drift. Erosion agencies have acted for a greater length of time, and the location of the present exposures of the drift is nearer major drainage lines. The Illinoian drift ironed out surface irregularities, chiefly

through the filling or partial filling of valleys.

The outer margin of the Illinoian drift in Indiana bears little evidence of a terminal moraine but is quite thin and patchy, and where covered with loess the boundary is difficult to trace. Outwash plains, lacustrine plains formed by ponding of ice, and their deposits are characteristics of the Illinoian boundary in southwestern Indiana.

The Illinoian till in its upper weathered portion is yellowish or reddish, but below a depth of ten or fifteen feet it is an unoxidized grayish mass. In it clay predominates, making a firm, compact, impervious mass, in which pebbles are relatively few and of small size. It has already been pointed out that the Wisconsin till contains less clay and more numerous and larger boulders, consisting largely of limestone, shale or other local rocks, though including many of granite or metamorphic rock not native to Indiana. It is believed that the lower and older drift is made up mainly of materials derived from the weathered rock surface over which the ice moved, the major part being from local rocks.

From the texture of the drift, its thinness, more mature dissection and position on bedrock, it is concluded that the Illinoian drift is not so good a water-bearer as the Wisconsin. Locally the Illinoian drift will bear water and in many areas is the chief source of supply. Erosion by streams has permitted water to drain from the drift in dissected areas.

The loess, locally known as yellow loam, yellow clay, etc., is a fine, nearly structureless silt. It is a yellowish buff color, somewhat plastic when wet, but is not a clay It occurs as a thin mantle overlying the Illinoian drift and is probably of aeolian origin. The upland loess areas are undoubtedly of wind origin, however, the loess which mantles the valley terraces may be of various origins and stream deposited.

The loess has been a source of supply for farm wells in some few counties where Illinoian drift was exposed at the surface, but drainage and cultivation have so lowered the ground-water level as to greatly lessen its importance. The subloessial sands lying beneath the loess and over the till yield a somewhat more plentiful but very uncertain supply. Both the loess and subloessial sands are liable to surface contamination. Altogether the loess of southwestern and southeastern Indiana is not a source of water supply of any considerable magnitude.

The outwash plains, valley trains and morainal deposits have been discussed in connection with the Wisconsin glaciation. These features are not so pronounced and since their formation, have been eroded and moved. Malott

(54) Malott, C. A., The "American Bottoms" Region of Eastern Greene County, Indiana, Indiana University Studies #40, 1919

has directed attention to the physiographic influence of the Illinois glacial lobe and its obstruction of the streams. Valley trains were formed in the valleys of both east and west forks of White River and outwash aprons formed in many of the smaller valleys. These barriers caused derangements in drainage.

PENNSYLVANIAN SYSTEM

The rocks of the Pennsylvanian system outcrop in western and southwestern Indiana. An area of approximately 8000 square miles has Pennsylvanian rocks at the surface or underlying either glacial drift or alluvium. The Pennsylvanian rocks have been divided into three divisions, Pottsville, Allegheny, and post-Allegheny. The total thickness of all the Pennsylvanian formations in the State is approximately 1300 feet. The Pennsylvanian rocks were formerly called the Coal Measures. Coal beds are common in the Pennsylvanian rocks, and, all Indiana coal is found in the Pennsylvanian strata.

Cumings(55) has given the history of the nomenclature of the Pennsylvanian strata and a resume of these geology of thes formations.

(55) Cumings, E. R. Nomemclature and Description of the Geological Formation of Indiana, Part IV, Handbook of Indiana Geology, 1922, Dept. of Conservation, State of Indiana, pp. 519-30.

Post-Allegheny Series. -- The Post-Allegheny Series of the Pennsylvanian is made up of a sequence of sandstones and thin seams of coal which are overlain by shales and thin limestone beds. The total thickness of the post-Allegheny formations is approximately 500 feet, consisting mainly of sandstones and shales with a few thin limestones and coals, the latter of little commercial importance. An unconformity at the top of Coal VII divides the post-Allegheny series from the underlying Allegheny series. This unconformity frequently cuts out Coal VII entirely.

Logan and others(56) have summarized these formations in the stratigraphic column accompanying the geological map of Indiana.

(56) Logan, W. N., et al., Geological Map of Indiana, Publication No. 112, Dept. of Conservation, State of Indiana, 1932.

Allegheny Series. -- The Allegheny Series of Indiana consists of approximately 450 feet of strata composed of sandy shales, sandstone, Coal III, Coal IIIa, Coal IV, Coal IVa, Coal V, Coal Va, Coal VI, Coal VII, and interbedded shales, fireclays, sandstones and limestones.

CHART SHOWING PENNSYLVANIAN FORMATIONS OF INDIANA*

PENNSYLVANIAN	Post-Allegheny	Wabash 250-300'	New Haven formation Buffkin formation Grayville formation McClearys Bluff formation Friendsville formation St. Wendells formation Parker formation
		Merom 75-90'	Merom sandstone and shale
		Shelburn 150-235'	Ditney formation West Franklin limestone Shale and sandstone interval Coal VIII Shale interval Busseron sandstone and shale
	Allegheny	Petersburg 180-300'	Coal VII Coal VI Coal Va Coal V Coal IVa
		Staunton 150-200'	Coal IV Coal IIIa Coal III
	Pottsville	Brazil 60-80'	Coal II Minshall Coal Upper Block Coal Lower Block Coal
		Mansfield 80-300'	Coal I

*The above chart is mainly a classification based on the occurrence of the more commonly recognized coal divisions of th State; also some of the better known sandstone and limestone strata are included where these units have been named. The reader will recognize the fact that there occur many shales, sandstones, limestones, and underclays interstratified with the above recognized horizons.

Most of the valuable coals of the State are produced from the Allegheny Series. The Block Coals are of Pottsville age and are quite important, however, the tonnage of the Allegheny Series coals is far greater, therfore, far superior in total value.

Pottsville Series. -- The Pottsville Series in Indiana consists of several coal strata, fireclays, shales, sandstones and limestones. Coal II, Minshall Coal, Upper Block, Lower Block and Coal I are included in the Pottsville series and overlie the Mansfield sandstone formations. It is estimated that the Pottsville in Indiana has a maximum thickness of approximately 400 feet. The total thickness in different areas, however, is quite variable, ranging down to less than one-half the maximum. The unconformity at the top of Coal II, which represents the interval between Allegheny and Pottsville time, appears frequently in the stratigraphic section, with Coal II entirely missing.

The Mansfield sandstone is the basal Pottsville formation of Indiana. It lies unconformably upon older rocks. In the region of Fenton and Tippecanoe counties these similar basal Pennsylvanian beds rest on Upper Mississippian (Chester series) formations. The Mansfield formation varies from a few feet to 280 feet in thickness. It rests with marked unconformity and overlap on older strata.

WATER SUPPLY FROM PENNSYLVANIAN STRATA

Pennsylvanian strata occupy almost twenty percent of the outcrop area of Indiana, disregarding the glacial drift. From a study of the many well records and the geologic column of the State, it is seen that the Pennsylvanian strata occupy about twenty-five per cent of the Indiana geologic column when considered vertically. It is difficult to give an average areal thickness for the Pennsylvanian system of rocks in the State for the reason that overlap prevails and the strata range from practically to thin feather-edge formation to a maximum of probably 1500 feet. The Pennsylvanian strata are thinner on the eastern margins and the thickness increases toward the Interior Basin of southern Illinois and southwestern Indiana.

The water supply of the large and varied Pennsylvanian system is peculiar in on respect. While heavy beds of sandstone such as the Mansfield, Merom, Busseron and others not named occur within this system of rocks, all of which would serve an admirable purpose as reservoir rocks, it is a fact that they are not considered aquifers over extended areas. The system contains many impervious layers of shale, fireclay, hard limestone bands and underclays below the coals which would serve as effective barriers against the loss of water. These impervious strata also serve as barriers to prevent downward penetration of water. The outcrops of the strata which are porous and capable of containing ground water are not widespread at the surface.

The Mansfield sandstone, which is the basal member of the Pennsylvanian in Indiana is a coarse-grained sandstone where typically developed. Frequently it is a conglomerate in the lower part and locally conatains small geodes and chert fragments, as well as the more common vein quartz pebbles. Characteristic features of the bed are its massiveness, the prevalence of false bedding and the occurrence of pebble beds, especially near the base. The distribution of the Mansfield was shown by Hopkins(57) to extend from Warren County southward to the Ohio River.

(57) Hopkins, T. C., The Carboniferous Sandstones of Western Indiana, 20th Annual Report, Indiana Department of Geology and Natural Resources, 1895, pp. 186-327.

The Mansfield varies considerably in thickness and is known to be extremely lenticular. These facts indicate that the Mansfield in one area might be an excellent aquifer and in still other areas would be effectively sealed by impervious strata. The Mansfield formation can be detected in a study of well logs in areas far removed from the outcrop. The formation retains its sandy character and invariably bears water, but the water is nonpotable. In Indiana the Mansfield bears fresh water at or near the outcrop, but at some depth below the surface and some distance from the outcrop the waters are unfit for use.

The Pennsylvanian strata of the southwestern part of the State are either unglaciated or covered to only a slight depth with drift, but in western Indiana they are so thickly covered that wells are either obtained in the drift or at the junction of the drift with the bedrock. Wells which have been sunk into the bedrock have in many cases struck "copperas water" at moderate depths, and salt water is usually encountered at depths of more than 200 feet. It is difficult to know the exact depth at which the fresh water horizon will disappear. Drilling test wells is the surest method of determining this horizon. Frequently objectionable waters occur in higher levels and fresh potable water are found lower in the geologic column. When this occurs the higher and objectionable waters may be cased off and the good water utilized. In some localities it seems necessary to use rain water collected in cisterns, the sulphates in the ground water being so generally present that good wells are very difficult to obtain.

Water supplies for farms and dwellings can usually be obtained everywhere in the Pennsylvainian outcrop area without seroius difficulty. Towns and cities which are located in this belt are confronted with a difficult situation, if forced to rely on ground water within the Pennsylvanian. The towns nearest to the eastern boundary of the Pennsylvanian system are more favorably situated in this respect than those which lie well within the Coal Measures. This is explained by the fact that near the boundary line uncovered feeding areas for the aquifers exist and the contained waters are not in contact with the bedrock for extended periods nor are they transported for great distances in contact with rocks of the character of the Pennsylvanian.

A large area in Posey, Vanderburgh, Warrick, Spencer, Dubois, Pike, Perry, Martin, Crawford, Orange, Greene and Monroe counties does not have glacial drift at the surface to act as storage beds. These counties have Pennsylvanian strata in all or part of their limits.

Many wells in the Coal Measures territory obtain water from the coal strata. The individual coal seams rest on an underclay which is impervious and permits the collection of water supplies in the joints and crevices of coal. The underclay deserves credit for this occurrence.

In many of the coal producing areas the waters are non-potable due to their high content of mineral matter. Sulphates are common in this area and many waters which come in contact with pyrite and other minerals are unfit for use.

Fortunately the towns and cities located within the Coal Measures have easy access to the great streams of the State. An inventory of the water supply situation in various cities shows that Evansville, Mt. Vernon, Petersburg, Washington, Terre Haute, Vincennes, and Princeton obtain municipal supplies from streams. Others obtain supplies from glacial drift, artificial lakes and river gravels and terraces. Within this belt the supplies which originate in the Pennsylvanian strata are very limited. Towns located miles from the outcrop of the Pennsylvanian sandstone strata cannot expect to secure supplies from these rocks. The Pennsylvanian formations are marine and contain within their interstices much connate water and as there is no chance for these concentrated brines to escape, they remain locked within the pores. Deep wells into the basal Pennsylvanian formations of Gibson and adjacent counties usually obtain saline artesian waters. It is possible that these rising brines are a source of pollution to horizons stratigraphically higher. Many oil and gas wells have been drilled in this area.

MISSISSIPPIAN SYSTEM

One of the most interesting and important systems of strata in Indiana is the Mississippian, composed chiefly of limestones, sandstones, and shales, underlying the coal-bearing beds of the State. Southwest of the Cincinnati Arch, the Mississippian system occupies an area of approximately 7100 square miles. These rocks outcrop at the surface, or are covered with residual materials or glacial drift. The area of Mississippian outcrops in the unglaciated portion of the State is approximately 3100 square miles, which is one-half of the Driftless Area. This leaves 4000 square miles of Mississippian strata which are covered or partially covered with drift, located southwest of the Cincinnati geanticline. The present geological map of Indiana by Logan and others (58) shows an area of approximately 1900 square miles

(58) Logan, W. N. et al., Geological Map of Indiana, Publication No. 112, Dept. of Conservation, State of Indiana, 1932.

of Mississippian in northeastern Indiana. These Mississippian rocks are deeply overlain by glacial drift and do not outcrop. The writer has determined that approximately 9000 square miles, which is one-fourth of the area of Indiana, have Mississippian strata at the surface or the first bedrock below glacial drift. Thus it can be seen readily that the strata of the Mississippian period bear an important relation to any consideration of the ground water supplies of Indiana.

The Mississippian rocks of the State extend from southeastern Newton County on the north to southernmost parts of Harrison and Perry counties on the south. The areal outcrop width at the north in Benton and White counties is approximately 25 miles, while in the vicinity of the Ohio River in Crawford, Harrison, and Floyd counties it is 50 or more miles in width.

Cumings (59) has given an excellent summary of the

(59) Cumings, E. R., Nomenclature and Description of the Geological Formations of Indiana, Part IV, Handbook of Indiana Geology, Publication No. 21, Dept. of Conservation, State of Indiana, 1922, pp. 475-519.

nomenclature and description of the Mississippian strata of Indiana down to 1922. Malott (60) has presented the detailed

(60) Malott, C. A., The Upper Chester of Indiana, Proc. Ind. Acad. Sci., Vol 34, 1924 (1925), pp. 103-32.

physical characteristics of the Upper Chester Series of southern Indiana. Stockdale (61) has published the latest data

CHART SHOWING MISSISSIPPIAN FORMATIONS OF INDIANA

MISSISSIPPIAN	Chester	Upper 0-280'	Shale interval Negli Creek limestone 0-20' Shale interval Mt. Pleasant sandstone 0-35' Gennet Creek formation 10-35' Bristow sandstone 0-25' Siberia limestone 0-20' Wickcliff sandstone 0-40' Shale interval 0-125' Tar Springs sandstone 0-40'
		Middle 0-160'	Glen Dean limestone 15-40' Hardinsburg sandstone 25-45' Goloonda limestone 10-40' Indian Springs shale 15-25' Cypress sandstone 30-45'
		Lower 0-170'	Beech Creek limestone 10-30' Elwren sandstone 10- 40' Reelsville limestone 1-10' Sample sandstone 20-30' Beaver Bend limestone 5-20' Mooretown sandstone 10-30' Paoli limestone 20-50'
	Meramec	80-160'	Ste. Genevieve
		100-240'	St. Louis
		0-70'	Salem
	Osage	Warsaw 60-95'	Harrodsburg
		Borden 420-750'	Edwardsville formation Floyds Knob formation Carwood formation Locust Point formation New Providence formation
	Kinderhook 0-10'		Rockford limestone

(61)
Stockdale, F. B., The Borden (Knobstone) Rocks of Southern Indiana, Publication No. 98., Dept. of Conservation, State of Indiana, 1931, 330 pp.

on the Borden group of the Mississippian of southern Indiana. Aside from purely scientific studies of the Mississippian system, it is important for the occurrence of the famous limestone, known far and wide to the trade as Indiana limestone. This is found in the Salem formation.

The Mississippian strata which underlie the glacial drift in northeastern Indiana do not come to the surface, but dip gently to the northeast and north. The Borden group of rocks is probably represented.

The area underlain by Borden rocks in northeastern Indiana is fortunate in having a thick mantle of glacial drift, numerous lakes, and some streams from which to secure water supplies. The Borden formations as a rule are not considered as aquifers. The New Albany black shale which underlies the Borden is not water-bearing, so that wells would of necessity be fairly deep before any formations bearing water would be penetrated. It is very likely that such deep wells would bear salt water unfit for use. The outcrop of the water-bearing formations is so far from the locality where any well might be drilled that fresh water would become saline before reaching the well. The Borden group of rocks is of marine origin and contains quantities of connate water, or at least derives salt from original salt water sources. It is true that the immediate contact with the glacial drift would be an excellent horizon for ground water, but, the drift is the source of the water.

Because the overlying glacial drift contains an abundance of fresh water of meteoric origin, the Borden strata must receive some water direct from the drift. Though relatively impervious the siltstones and shales of the Borden contain small quantities of water. Wells drilled into these formations do not obtain sufficient water for ordinary household purposes.

CHESTER SERIES

Malott describes the Chester series as follows:

"The Chester series form the uppermost unit of the Mississippian system of the Mississippi valley. The Chester series are represented in Indiana by a number of formations which outcrop in the southwestern part of the state in a general north and south direction, extending from near Greencastle, Putnam County, to the Ohio River at the southern boundaries of Harrison, Crawford, and Perry counties. In the vicinity of Greencastle only a few feet of strata are present beneath the Mansfield sandstone, the basal member of the Pennsylvarian system. Southward the thickness increases. Near French Lick in western Orange County the thickness has increased to a total of about 250 feet. In Perry County at the southern boundary of the state the total thickness has increased to approximately

)0 feet. Only the lowest members of the series are present in ıtnam County at the northernmost outcrops. Southward younger embers appear beneath the overlapping Mansfield sandstone, ıd the maximum number of formations is attained in the vicinity ' the Ohio River. The areal outcrop width at the north is but few miles, while in the vicinity of the Ohio River it is) to 30 miles in width."

Malott (62) recognizes six units, in the upper Chamber:

:2) Malott, C. A., The Upper Chester of Indiana, Proc. Ind. Acad. :i., Vol. 34, 1924 (1925). pp. 103-32.

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our sandstones and two limestones, and much shale. This succession is shown on the accompanying chart.

As the Upper Chester is composed principally of shales, ound water would not be expected to occur in abundance owing to e nonporosity of shale. The four sandstone beds of this group ould contain water, but by virtue of their lens-like character, mited outcrop area in a region maturely dissected and adjacent the Ohio, they, in all probability, could not be much used. he proper set-up for natural springs is found very frequently the entire Chester outcrop belt. Water-bearing strata are derlair and overlain by impervious shales, which with the p of the rocks gives the correct conditions for artesian springs d wells. Wells must be of sufficient distance from the outcrop the aquifer, if they are of the flowing type, to build up fficient static head.

The Middle Chester group consists of five units; two mestones, two sandstones and one shale. The total average icknoss of the group is about 150 feet. This group has thologic characteristics which persist over wide areas.

The Chester Series as a whole is noted for the occurrence natural springs. Dr. Malott has remarked to the writer that his opinion there is no other known area in the United States ich will average to the square mile so many springs as does the ester outcrop belt. A study of the Chester Series, especially e Middle and Lower divisions which consist largely of alternang limestones and clastics, will explain the geological asons for this condition. The sandstones, and limestones which e porous and contain water, are underlain by impervious shales. ter is transported down the dip and downward until the basal rtion of the water-bearing formation is saturated. If at any int the water table is intersected by the surface a spring sults. The Chester formations comprise a large portion of the awford Upland of southern Indiana, which is the region of eatest relief within the State. Therefore many streams have t down through the Chester strata exposing water-bearing beds th resulting springs.

Several public water supplies in southern Indiana are derived from springs in the Chester Series. English has for years received a supply of water from springs flowing out of the Beech Creek limestone. The overlying porous Cypress sandstone feeds water to the Beech Creek which conveys the water to the springs. These usually issue at the base of the Beech Creek.

The abundance of springs which issue from the Chester formations indicates that ground water is present. The springs, while not large, do not vary greatly in volume and rarely go dry even in the driest summers. Wells drilled into the Chester sandstones and limestones usually obtain sufficient water for the purpose for which drilled, which is usually to supply a household. No large public supplies are known to be produced by wells drilled into the Chester formations.

MERAMEC SERIES

The following subdivisions of the Meramecian series are recognized in Indiana:

Ste. Genevieve	80-160'
St. Louis	100-240'
Salem	0- 70'

The above three limestone formations together with the underlying Harrodsburg limestone constitute the limestone belt of southern Indiana. It is the region of karst, of underground drainage and the outcrop area of these formations is expressed in the Mitchell Plain as previously described.

The Salem formation contains the famous Indiana building stone of Lawrence, Monroe and Owen counties.

In distribution the limestone formations extend from northern Putnam County to the Ohio River, through middle Putnam, eastern Owen, Middle Monroe, Lawrence, northeastern Orange, western Orange and Harrison counties. The outcrop belt is narrow at the north, being only a few miles in width. At the south it is approximately 20 miles in width.

In this discussion the Harrodsburg formation of the Warsaw division of the Osage series will be included, since the strata are similar to the limestones above it and water problems of the Harrodsburg are like those of the Meramec Series.

In general structure the Mitchell Plain limestone belt shows a uniform westward dip. It is on the southwest of the Cincinnati Arch and the strata dip toward the Illinois basin. The average dip is from 30 to 40 feet per mile, and the strike is a very few degrees west of north. The Mississippian strata present some interesting problems. The Chester Series

increases in thickness from north to south. The Borden (Knobstone) group described by Stockdale increases in thickness from south to north. (63). The Meramec Series increases in

(63) Stockdale, F. B., The Borden (Knobstone) Rocks of Southern Indiana, Publication No. 98, Dept. of Conservation, State of Indiana, 1931 p. 61.

thickness from north to south, as indicated by the ever increasing width of the outcrop from north to south.

The Ste. Genevieve and St. Louis formations of the Meramec Series consist of limestones with occasional beds of chert and shale. The shale is characteristic of the lower 40 feet of the St. Louis formation. The chert occurs as nodules, stringers, and as layers. One rather persistent horizon near the base of the Ste. Genevieve limestone contains oolitic beds and in places in the upper part contains a sandy zone which in places is a limy sandstone as much as 10 or 12 feet thick. The St. Louis below the Ste. Genevieve, is nowhere known to be oolitic. Beds in both the St. Louis and the Ste. Genevieve are characteristically quite dense and border on lithographic limestone.

The areas occupied by the Mississippian limestones in southern Indiana and Illinois, also in Kentucky, Tennessee and Missouri constitute a notable area of karst. The Ste. Genevieve and St. Louis formations are noted for their development of underground drainage. Caverns of national reputation, notably Wyandotte, Mammoth, and Marengo have been formed in these soluble limestones. Lost River (64) in southern Indiana, which

(64) Malott, C. A., Lost River at Wesley Chapel Gulf, Orange County, Indiana, Proc. Ind. Acad. Sci., Vol. 41, 1931(1932) p. 285-316.

flows for more than seven miles underground is one of the remarkable features of southern Indiana karst which is developed in the top of the St. Louis limestone near the contact with the overlying Ste. Genevieve limestone. The rise of Lost River at Orangeville may be considered as a tremendous spring, but of a special type, peculiar to regions in which subterranean drainage has been developed. Malott's study of Lost River at Wesley Chapel Gulf in Orange County brought out the fact that the bedded limestone of the karst region is traversed by two intersecting joint systems, one of which extends northeast-southwest and the other northwest-southeast. Percolating ground water moves through the joint fractures and along the bedding planes of the strata. It is not believed that much ground water could possibly move through the dense limestone beds. Lost River is known to follow a complex system of channels both vertically and horizontally. The action of the moving waters through the joint and bedding plane conduits has been responsible for the development of these subterranean passageways which have been aided in their growth, and enlargement by the solvent effect of ground water below the level of the water table.

The geological conditions of water supply in the limestone region have several points of interest. Attention has already been directed to the presence of subterranean drainage. Surface streams are wanting in many areas, especially those underlain by the Ste. Genevieve and St. Louis formations. The Salem and Harrodsburg limestones are much less subject to the development of underground drainage. One or two limestone horizons in the overlying Chester Series have underground drainage locally developed but owing to associated shales and sandstones, the occurrence of underground conduits in the Chester can never reach the magnitude and importance of those of the St. Louis and St. Genevieve. Relief in the Mitchell Plain area is low, but the typical Mitchell Plain, as named by Beede and which has an areal extent of 1125 square miles in southern Indiana, is developed near the top of the St. Louis limestone. Relief of the entire Meramecian Series is greater. Malott (65) has pointed out that

(65) Malott, C. A., Physiography of Indiana, Part II, Handbook of Indiana Geology, Dept. of Conservation, Publication 21, State of Indiana, 1922, p. 96.

the Mitchell Plain is not co-terminous with the areal extent of the so-called Mitchell limestone. The term Mitchell limestone in earlier geological reports referred to the Paoli limestone of the Chester Series, and the Ste. Genevieve, and the St. Louis Limestones.

Meinzer (66) has pointed out that no rock differs more

(66) Meinzer, O. E., The Occurrence of Ground Water in the United States, U. S. Geol. Survey Water-Supply Paper 489, 1923, p. 131.

radically with respect to yield of water than limestone. Some limestone formations rank among the best aquifers; others are as unproductive as shale. These differences are in part due to the original texture and nonporosity of the rock and in part due to the modification undergone by the rock during the processes of solution. There is a wide range in the yield of different formations of limestone and of the same formation in different localities. A study of the individual wells of a locality, which obtain water from a given horizon, shows that even these wells vary in yield. In limestone aquifers the size of the joint crevices and solution passageways determines the water-bearing capacity of the wells. One well may penetrate a large crevice and thus obtain an abundant supply, whereas an adjacent well located just a few rods away may be practically dry and will not furnish enough water for a household. The element of chance plays a prominent part in the success of any well drilled in the limestone region.

The thick-bedded limestones of the Mississippian of southern Indiana are generally very dense and it would seem impossible for water to percolate through these beds. The primary pore space of these rocks is negligible. The secondary

pore space is that due to joints, solution along bedding planes, porosity related to the development of unconformities and due to voids produced by the processes of crystallization and also joint crevices made by faulting and compression of the beds. Howard [67] has given a classification of limestone reservoirs.

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(67) Howard, W. V., A Classification of Limestone Reservoirs, American Assoc. of Petroleum Geologists Bulletin, Vol. 12, 1928, p. 1155.

Limestone is defined as a rock which was laid down beneath bodies of standing water and originally consisted of relatively pure calcium and magnesium carbonate which has not been metamorphosed.

Howard's classification is given in full as follows:

"Porous limestones may be classified according to the origin of their porosity as follows.

1. Limestones with primary porosity

   a. Chalk
   b. Oolitic limestone
   c. Primary crystalline dolomite and limestone
   d. Coral reefs

2. Limestones with secondary porosity

   a. Limestone associated with former erosion surfaces
   b. Limestone with porosity developed as a result of mineralogical changes

3. Fractured limestones

   a. Strongly jointed limestone
   b. Limestone fractured as a result of crustal movement
   c. Limestone fractured as a result of mineralogical changes."

Howard's study was made in connection with the occurrence of oil in limestone reservoirs. It is interesting to note that he states that limestones with secondary porosity are the reservoirs which contain perhaps as much as 95 per cent of the oil found in reservoirs of limestone. The one in which porosity has been developed below former erosion surfaces is the main one and reservoirs formed by mineralogical change are relatively unimportant. Oil also occurs in fractured limestones, a case being the production from near Terre Haute, Indiana. The Trenton limestone production of eastern Indiana and Ohio is probably related to an unconformity. This is of Ordovician age and is simply mentioned here in connection with the discussion of limestone porosity.

The development of underground drainage in the limestone belt of southern Indiana is responsible for the many springs existing in this area. Streams disappear and then reappear as springs on the western border of the area. Lost River has been mentioned as a stream of this type. Other springs, which have no known direct association with surface waters, are abundant in the area. Meteoric waters fell as rainfall and penetrated the underground conduits and then later appeared as spring water with certain minerals in solution which came from the rocks through which the water passed. The famous springs at West Baden and French Lick are located on strata of Paoli age, which is the basal formation of the Chester Series. It is believed that the water comes from the underlying Ste. Genevieve and St. Louis limestones and receives its mineral content from these rocks.

About fifty feet above the base of the St. Louis limestone is a layer of impervious rock which serves as a floor for many of the caves of the region and also as a spring horizon. Water cannot go downward so it moves laterally. The Leonard and Shirley springs west of Bloomington and the Stone spring nearer Bloomington emerge at this horizon. The Fish Hatchery spring at Avoca in Lawrence County is also at this horizon. This particular spring flows a copious stream of water during the wet and rainy seasons but when prolonged drought conditions prevail the flow is small. This proves that the volume of water is dependent on the rainfall and the level of the water table. When the water table is lowered, due to diminished surface supplies, the spring volume flow is diminished.

Other important spring horizons are at the contacts of the Salem and St. Louis limestones and the Harrodsburg and Salem limestones. Many springs are found at these stratigraphic horizons, though none of them is large.

Still another important spring horizon is at the base of the Harrodsburg limestone, or at the top of the Borden group. The Harrodsburg limestone is included in the Osage Series but is discussed with the overlying limestone series. The Harrodsburg limestones are well jointed, which fact permits water to flow. The rock itself is dense and while it has a certain degree of porosity and contains some water, wells could not be expected from the limestone rock without the accompanying joints and crevices for conduits. Many perennial springs exist at this Harrodsburg-Borden contact. The writer has observed several springs at this horizon which did not fluctuate even during period of prolonged drought. These springs, which are never large, are valuable resources for domestic and stock water supplies. The Borden group of formations, which underlies the Harrodsburg limestone, is relatively impervious and the water flows laterally emerging as a spring when intersected by the surface.

Indirectly associated with ground water is the fact that it is not feasible to attempt the construction of artificial reservoirs in regions underlain by limestones. This has been demonstrated by the city of Bloomington, which after a period of

costly experimentation resorted to a reservoir constructed in the nearby Borden outcrop belt.

Most of the larger towns located in the limestone belt do not obtain water from the limestone formations. Greencastle, Spencer, Bloomington, Bedford, Oolitic, Ellettsville, and Gosport are included in this list. Many towns throughout the district get potable water in sufficient quantities from the limestones. Included in this list of towns are Salem, Orleans, Corydon, and Cloverdale. English and Corydon report supplies from natural springs. Lanesville also utilizes spring supplies.

While it has been stressed that public supplies of sufficient quantity cannot be obtained from the limestone beds by ordinary wells, it must not be construed that there cannot be used these same formations for private supplies. Private wells which secure water from limestone strata occur by the hundreds in the belt, and where the water does not become turbid after each rain and a surface pollution source is not evident, the limestone waters are of good quality. However, where cloudy water results after a rain and where sinkholes lead directly into the source of supply, some question should arise as to the desirability of procuring water from such sources.

The following chart shows the present classification of the Osage Series of Indiana. Cumings (68) has reviewed the

(68) Cumings, E. R., Nomenclature and Description of the Geological Formations of Indiana, Part IV, Handbook of Indiana Geology, Dept. of Conservation, State of Indiana 1922, pp. 487-99.

history of the nomenclature of these formations and has given brief descriptions of them. The Harrodsburg limestone has been correlated with the Warsaw of Illinois and other States nearby. The Harrodsburg formation includes some 60 to 90 feet of rather coarse-grained, irregularly bedded limestone, often quite cherty, and in the basal portion are some shaly beds and impure limestones with abundant geodes.

OSAGE SERIES

	Warsaw	Harrodsburg
Osage Series	Borden	Edwardsville formation Floyds Knob formation Carwood formation Locust Point formation New Providence formation

Stockdale (69) has divided the Harrodsburg formation

(69) Stockdale, P. B., Stratigraphic Problems Involved in Determining the Geologic Structure in the Lower Mississippian Outcrop Area of Southern Indiana, Proc. Ind. Acad. Sci., Vol. 41, 1931 (1932) pp. 323-38.

into an Upper and Lower Harrodsburg. The Upper member consists of thin to massive limestone beds, often exhibiting false bedding on weathered surfaces. It ranges in thickness from 30 to 50 feet. The contact with the overlying Salem formation is conformable.

The Lower Harrodsburg unit consists of a very impure calcareous "bastard rock." It is characterized by the presence of many geodes and chert fragments. Lenses containing abundant crinoid fossils are characteristically present. The contact between the Lower Harrodsburg and underlying Borden is conformable and this exact contact is often difficult to recognize in the field. The lower member of the Harrodsburg unit ranges from 25 to 40 feet in thickness.

The water bearing capacity of the Harrodsburg formation has been discussed with the other prominent limestone formations of southern Indiana. Stockdale's recent work on the Harrodsburg formation would indicate that the ground water which is found along solution planes and joints in the Harrodsburg occurs in the upper member, and that many of the spring horizons, usually considered at the contact between the Borden and the Harrodsburg in reality may occur at the junction of the Lower and Upper Harrodsburg members.

The Borden group of the Osage Series occupies a wide belt extending from southeastern Newton County to the Ohio River at New Albany. The outcrop belt is just a few miles in width in Floyd County but increases northward and is as much as 35 or more miles in Benton County. In Brown County, Monroe County and Bartholomew County the Borden strata have been found to be some 25 to 30 miles across the outcrop and are 760 to 765 feet in thickness at Nashville. The Borden strata are approximately 425 feet thick in southern Harrison County and well records show [illegible] a total of 650 feet of Borden in Monroe County. This indicates a thickening northward and eastward for the entire group which is exceptional. A cursory examination of the geologic map of Indiana shows that the Borden persists as far as it can be traced northward under the glacial drift. Stockdale pointed out the thickening northward and eastward as far as the glacial drift boundary.

Various writers have pointed out the conditions which exist insofar as ground water occurs within the Borden strata. The rocks contain ground water, though transmit it very slowly. The siltstones, fine-grained sandstones, shales and clays predominate in the lithologic analysis of Borden sediments. The clastic sediments are primarily silts and clays which have become indurated. The pore spaces between the individual

particles making up the rock are exceedingly small. No coarse-grained sandstones are found. Stockdale[70] has described in

(70) Stockdale, P. B., The Borden (Knobstone) Rocks of Southern Indiana, Publication 98, Dept. of Conservation, State of Indiana, 1931, 330 pp.

detail the stratigraphy of the Borden group of Indiana.

Stockdale has pointed out that in many places, especially in Clark County, the shale of the New Providence formation contains a noticeable amount of readily soluble salts, particularly sodium chloride and magnesium chloride.

> "Evidence of this is seen in the numerous so-called "licks" where cattle congregate and lick the shale exposure because of its salty taste. Such a well-known shale bank is near the center of lot 274. It has been named "Deer Lick" because, according to claims of early settlers, deer used to frequent the exposure. Occasional wells located in the New Providence shale contain water which is so strong in dissolved minerals that it is unfit for drinking. Medicinal values have been claimed for some of the waters. Probably the best known of the mineral wells are those of the vicinity of Henryville. Analysis of the water from a "mineral well" located in the S. E. ¼ Sec. 21, T. 2 N., R. 7 E., three-fourths of a mile southeast of Underwood, follows.

Potassium bromide	3.4 parts in one million
Sodium chloride	203.7
Sodium sulphate	787.9
Magnesium sulphate . . .	777.5
Magnesium bicarbonate . .	153.7
Calcium bicarbonate . . .	534.9
Calcium phosphate	65.5
Manganese bicarbonate . .	10.2
Ferrous bicarbonate . . .	32.9
Silica	12.6
Total.	2582.3"

Blatchley[71] has described four mineral springs from

(71) Blatchley, W. S., Mineral Waters of Indiana, 26th Ann. Rept. Ind. Dept. of Geology and Natural Resources, 1901, pp. 31-6.

Clark County which have water coming from the basal portions of the Borden Group.

KINDERHOOK SERIES

The sole representative of the Kinderhook Series in Indiana is the Rockford limestone. The limestone formation is quite thin varying from zero to ten feet in thickness. The contact of the Rockford with overlying Borden sediments is definite and in Indiana this contact appears to be conformable. The Rockford limestone is a ferruginous, brownish or greenish gray stratum. The type exposure is in the bed of White River at Rockford, Jackson County. It has been famed for the unusual goniatite fauna which is well preserved in it. Due to the character of this formation it is not considered an aquifer. Jointed limestone make excellent water-bearing beds, though the Rockford is quite thin and overlain by the relatively impervious New Providence shale of the Borden group. Water which might percolate through these shales might give rise to some water in the Rockford limestone, though any water from the Borden is likely to be unfit for use. The Rockford is underlain by the Devonian (New Albany) black shale, which is practically impervious. The thinness of the Rockford stratum, which even with the gentle dip of these formations in Indiana permits a very narrow outcrop belt, precludes the possibility of the Rockford's being considered for its water possibilities. Locally, where streams have cut through the overlying formations and exposed the Rockford, it is water-bearing but owing to its thinness cannot have much storage capacity.

DEVONIAN

Devonian strata are widely distributed in the State, either in outcrop or immediately below glacial drift. They extend from Jeffersonville on the Ohio River northwestward to Morocco in central Newton County. The outcrop belt is ten miles in width in northwestern White County, 35 to 40 miles in Johnson, Rush and Shelby counties, and about nine miles at the north border of Clark County. This is the main outcrop belt southwest of the Cincinnati geanticline.

North and Northeast of this prominent subsurface structural feature of Indiana occurs another area of Devonian strata. There are no outcrops in this northern area, but well records show the presence of Devonian strata below the drift in an area of approximately 4140 square miles. The Kenneth limestone is described and the stratigraphical relations are discussed by Cumings and Shrock.(72) The Kenneth formation is found only in

(72) Cumings, E. R. and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Dept. of Conservation, State of Indiana, 1928, pp. 123-35.

the structural sag between Peru and Logansport.

r. E. R. Cumings (73) has expressed the opinion that the fauna

73) Cumings, E. R., Silurian Studies, Paper No. 3, Lists of pecies from the New Corydon, Kokomo, and Kenneth formations of ndiana, and from reefs in the Mississinewa and Liston Creek ormation, Proc. Ind. Acad. Sci., Vol. 39, 1929 (1930), p. 208.

f the Kenneth limestone of northern Indiana is comparable with arly Devonian faunas (Keyser) in Maryland, Pennsylvania and New ersey. The Kenneth is therefore probably Lower Devonian.

Southwest of the Cincinnati geanticline, the Devonian strata over an area of 4229 square miles. Most of this area is mantled ith glacial drift. It is interesting to observe that about one-alf of the Devonian belt is occupied by the New Albany shale ormation and the other half by the Middle Devonian limestones.

The northern Indiana Devonian consist mainly of the New lbany shale, though this conclusion is based on well records hich are none too numerous for detailed work. The distribution f the formations shows that the Middle Devonian limestones are uite thin or have exceptionally steep dips and that the New lbany shale is much thicker or has more gentle dips. The distri-ution of the formations is based on information contained on the eological Map of Indiana, Publication 112, Department of Conser-ation, State of Indiana, 1932.

The total outcrop area of Devonian strata in the State is 369 square miles. This is approximate, and future detailed work ill no doubt alter these figures. When it is considered that ractically 5000 square miles are below the drift or have at the rface New Albany shale, which is not an aquifer, the importance o water supply becomes apparent.

GEOLOGICAL SECTION OF DEVONIAN OF NORTHERN INDIANA

System	Series	Correlation	Formation
Devonian	Senecan	Portage	New Albany shale
		Genesee	
	Erian	Onondaga	Jeffersonville limestone
		Schoharie	Pendleton sandstone
	Helderbergian	Keyser	Kenneth limestone

Devonian Stratigraphy of Northern Indiana

The New Albany shale and the Jeffersonville limestone do not outcrop in northern Indiana northeast of the Cincinnati Arch or northeast of the Kankakee Arch. As so few outcrops of these formations occur in northern Indiana, they will be described and their water-bearing properties more fully discussed in succeeding pages relating to the Devonian of southern Indiana. The type localities of both formations are in southern Indiana.

Pendleton sandstone.-- The Pendleton sandstone has been described and correlated with the Schoharie grit of New York State. In Indiana a single isolated outlier at Pendleton in Madison County is the only outcropping representative of this subdivision. The true significance of the formation and its occurrence is not understood. Well drillers have recorded the presence of about ten feet of sandstone near the base of the Devonian section in many wells of northern Indiana. Its distribution and paleogeographic relationships are difficult of determination owing to the lack of surface exposures and the meagre evidence obtained from well records.

Kenneth limestone. -- The Kenneth formation is the basal formation of Devonian age in Indiana and is probably very early Devonian. It is found in the structural sag between the northwestern end of the Cincinnati Arch and the southeastern end of the Wisconsin-Indiana geanticlinal structure. The latter structure is known as the Kankakee Arch. The Kenneth formation is a lithographic, irregularly-bedded, very cherty limestone. The formation varies from a few feet to as much as 40 feet in thickness. The joint and bedding planes of this formation are aquifers and where penetrated produce ground water. The overlying formations permit water to penetrate the Kenneth limestone. Frequently it is impossible from well records to distinguish the unconformable contact of the underlying Silurian (Kokomo limestone) formation. This contact is water-bearing and many wells are listed as producing from the Devonian and Siluria limestones. The exact horizon from which the water comes is not definitely known.

Devonian Stratigraphy of Southern Indiana

Northward from Clark and Jefferson Counties the stratigraphic relations of the Devonian limestones are not well known. Limestone strata are known to occur below the New Albany shale which extends across the State northwestward, but because of a scarcity of exposures and the deep mantle of glacial drift the sections cannot be studied in detail. At Indianapolis the Devonian limestones occur just below the glacial drift and are water-bearing. The western portion of Indianapolis is underlain by New Albany shale which is not an aquifer. The Devonian limestones which underlie the drift in northern Indiana bear ground water. Also where the limestone strata are overlain by the New Albany shale and where the limestones are not far removed from their outcrop below the drift, potable water is foun

Down the dip westward from the outcrop belt of the Devonian limestones, wells have penetrated the same formations only to find them charged with mineral waters. At Montezuma in western Parke County a well penetrated a limestone immediately below the Devonian shales and an artesian flowing well resulted. This stratum is in the proper stratigraphic position of the Devonian limestone.

A well was drilled on Lake Michigan, north of Laporte. At 292 feet a strong flow of "blue lick" water was encountered. This was reported in Devonian shale. At 387 feet, in the Silurian limestone, was found additional "white sulphur" water, and saline water was found at 630 feet. This well has been described by Blatchley. (74)

(74) Blatchley, W. S., The Mineral Waters of Indiana, 26th Ann. Rept. of Indiana Dept. of Geology and Natural Resources, 1901, p.73.

GEOLOGICAL SECTION OF DEVONIAN OF SOUTHERN INDIANA

System	Series	Correlation	Formation
Devonian	Senecan	Portage Genesee	New Albany shale
	Erian	Hamilton	Beechwood limestone Silver Creek limestone
		Onondaga	Jeffersonville limestone

New Albany shale. -- The New Albany shale is the uppermost member of the Devonian of Indiana. It is a dark gray to black shale. Well records show that the New Albany is from 75 to 150 feet in thickness. It is a marker which is easily recognized in wells and on the outcrop. The Devonian shales extend from Newton County on the north to Clark County on the Ohio River. The Scottsburg Lowland physiographic unit corresponds approximately to the outcrop area of the New Albany shale as far north as the Wisconsin drift.

The New Albany shale has always been known as a relatively impervious formation. The shale contains pyrite and other minerals which can be acted upon chemically by ground water. In many areas the New Albany is highly jointed. Reeves (75) has

(75) Reeves, J. R.; Oil Shales of Indiana, Part VI, Handbook of Indiana Geology, Publication No. 21, Dept. of Conservation, State of Indiana, 1922, pp. 1063-98.

described perfect joints in the New Albany shale which extend vertically through the shale for as much as 70 feet. While there are no records showing springs or ground water issuing from such joints, it is conceivable that if glacial drift overlay such an area, the proper conditions for ground water occurrence would be present. Of course, where drift concealed the entire shale body the element of chance would be a large factor in obtaining a successful well in a shale joint filled with water.

The New Albany shale is compact and homogeneous and fairly hard. Pore space in the shale is indeed small and it is believed that ground water could not circulate through the shale. It contains water in small quantities, but certainly cannot be considered as water-bearing.

In places throughout the New Albany formation occur thin lenses of sandstone and sandy shales. Usually these sandstone layers occur within a few feet of the base of the formation, and occasionally these sandy zones are charged with gas, oil, or salt water. It also has been observed that where important sections of the shale have been exposed to the weathering agencies of the atmosphere for a long time a certain measure of permeability has been gained by them through the superficial enlargement of the joints and by solution of some of the contain minerals. Pyrite is the most abundant mineral which has been decomposed. Most black shale water found in springs or wells is highly mineralized with iron sulphide, aluminum sulphate, and hydrogen sulphide, or other compounds of sulphur. The Middle Devonian or the Erian Series of southern Indiana is subdivided into the Beechwood, Silver Creek and Jeffersonville limestones, in descending order.

Beechwood limestone. -- The Beechwood limestone is a hard massive, coarsely crystalline crinoidal limestone, and is usuall quite thin. In Clark County, according to Huddle and Whitlatch(

(76) Huddle, J. W. and Whitlatch, G. I., The Stratigraphy and Structure of a Devonian Limestone Area in Clark County, Indiana, Proc. Ind. Acad. Sci., Vol. 41, 1931 (1932), pp. 363-90.

this formation averages about four feet in thickness. It is a persistent formation. It lies unconformably below the New Alban shale, and has a conglomerate band at the base. Under proper conditions the joints of the Beechwood with the sandy conglomera basal portion would make an aquifer and spring horizon. The formation is thin and would not serve as a large reservoir, unless in contact with glacial drift or alluvial deposits which could furnish water supplies.

Silver Creek limestone.--The Silver Creek limestone is a fine-grained, thin-bedded, homogeneous, clayey, magnesian limestone. It averages 15 feet in thickness, but the thickness is variable. Butts (77)has called attention to the disconformity

(77) Butts, Charles, Geology of Jefferson County, Kentucky, Ky. Geol. Survey, Ser. IV, Vol. 3, Part 2, 1915.

between the Beechwood and Silver Creek. The Silver Creek thins northward and cannot be traced farther north than Scott County. Siebenthal (78) described the Silver Creek formation in 1900.

(78) Siebenthal, C. E., The Silver Creek Hydraulic Limestone of Southeastern Indiana, 25th Ann. Rept., Ind. Dept. Geol. and Natural Resources, 1900, pp. 333-89.

Jeffersonville limestone. -- The Jeffersonville limestone, which is the basal member of the Indiana Devonian section, is composed of an upper shaly fossiliferous limestone, a middle, white to blue-gray, hard, massive limestone, and a lower brown, crystalline limestone which forms the famous coral biostrome of the Falls of the Ohio. The entire Jeffersonville is about 30 feet in thickness, but Siebenthal points out that it thickens northward.

The limestone formations of the Middle Devonian are water-bearing in many areas. Huddle and Whitlatch (79)mention an

(79) Huddle and Whitlatch, Op. Cit., p. 381.

exposure of the lower eight feet of the Jeffersonville limestone in a spring in the northeast corner of the northwest quarter of the northeast quarter of Section 92, Clark County, west of Charlestown. Also a spring is reported in Section 114, from a joint crevice near the top of the Jeffersonville limestone. Still another spring is reported from the Jeffersonville limestone in Section 94, Clark County. The formation is 28½ feet thick at this place.

The Devonian limestones of southern Indiana are water-bearing and supply many homes with water. The limestones, especially the Beechwood and Jeffersonville, are porous. The clayey Silver Creek contains joint crevices, similar to those of the other formation, but is not so porous.

SILURIAN SYSTEM

The rocks of the Silurian system cover a wide area in the State of Indiana, either at the surface or immediately below the glacial drift. All of the Silurian strata are within the glaciated area, and where now exposed by erosion the rocks occupy only restricted outcrops. Silurian strata are exposed at many points along the Wabash, Mississinewa, Salamonie, and White rivers, and in southeastern Indiana in Jefferson, Rush, Shelby, Ripley, Fayette, Franklin, Decatur, Jennings, and Clark counties. The writer has determined that Indiana has 8900 square miles of Silurian outcrop area, disregarding the glacial mantle rock. This is almost twenty-five per cent of the total area of the State. Silurian strata cap the Cincinnati Arch in north central Indiana. They cover a width of almost 100 miles between Noblesville in Hamilton County and Woodburn in northeastern Allen County.

The thickness varies from place to place, from about 66 to 660 feet.

The Silurian system in Indiana is everywhere unconformably below the Devonian rocks.

SILURIAN OF NORTHERN INDIANA

Chart Showing Silurian Stratigraphic Units in Northern Indiana

System	Series	Correlation	Formation
Silurian	Cayugan	Bertie-Akron	Kokomo limestone
		Guelph Lockport	Huntington dolomite
	Niagaran	Waukesha	Liston Creek limestone (includes Red Bridge)
		Rochester	Mississinewa shale

The Silurian strata of northern Indiana are found outcropping in the valleys of the Wabash and White rivers and tributary streams. Owing to the development of bioherms (reefs) in the region and the prevailing misconceptions concerning these interesting structures the stratigraphy of the northern Indiana Silurian was for a long time little understood.

It remained for Cumings and Shrock (80,81,82) to unravel the

(80)
Cumings, E. R. and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Dept. of Conservation, State of Indiana, 1928, 226 pp.

The Silurian Coral Reefs of northern Indiana and Their Associated Strata, Proc. Ind. Acad. Sci., 1926., Vol. 36, pp. 71-85.

The Niagaran Coral Reefs of Indiana and Adjacent States and Their Stratigraphic Relations, Bull. Geol. Soc. America, Vol. 39, 1928, pp. 579-620.

(81)
Cumings, E. R. Silurian Studies, Proc. Ind. Acad. Sci., Vol. 39, 1929 (1930), pp. 183-211.

(82)
Shrock, R. R., A New Graptolite Fauna from the Niagaran of Northern Indiana, Amer. Jour. Sci., (5) 16, pp. 1-38.

Some Interesting Physiographic Features of the Upper Wabash Drainage Basin in Indiana, Proc. Ind. Acad. Sci., Vol. 37, 1927, pp. 125-39.

stratigraphic succession, interpret the coral reef structures and study the faunas. The information presented herewith on the northern Indiana Silurian is abstracted from their comprehensive studies.

Kokomo limestone. -- The Kokomo limestone, the youngest Silurian formation in northern Indiana, is found in the Logansport structural sag. In Miami, Cass, Carroll and Howard counties the Kokomo limestone overlaps several underlying formations. It consists of an even-bedded, impure, magnesian limestone, argillaceous in the lower portions and more limy in the upper part. The thickness varies from only a few feet to as much as 60 feet.

The Kokomo limestone is water-bearing. In a few places springs are found at the contact of the Kokomo limestone and the underlying formations. In the city of Kokomo a small spring occurs at the disconformable contact between the Kokomo limestones and the Mississinewa shale. The exposure is located in the Markland Avenue quarry.

An average of three analyses of the Kokomo limestone shows the constituents which may be dissolved by ground or surface water.

Calcium carbonate	68.73%
Magnesium carbonate . . .	19.58
Silica	10.12
Ferric oxide and Alumina .	1.53
Total	99.96

When it is recalled that the hardness of Indiana water is due largely to the presence of calcium and magnesium salts, commonly called lime and magnesia, the source of some of these salts can be readily seen.

Huntington dolomite. -- "The Huntington formation is typically a massive to slabby, evenly-bedded, yellowish, gray or pinkish, granular dolomite of saccharoidal texture. At two localities, however, (certain exposures at Huntington and near Georgetown) the formation is represented by nearly pure, pink, crystalline limestone."

"On an unweathered surface the formation is conspicuously massive, but upon prolonged weathering, the stone becomes slabby, changes in color to a medium gray, and becomes very porous. The change in color, due to weathering, is brought out strikingly at Monon, where the dark unweathered stone, saturated with petroleum, contrasts with almost snow-white weathered dolomite."

The Huntington dolomite is about 150 feet thick at Huntingt In the Fort Wayne wells, it is about 450 feet thick and is belie to be several hundred feet thick toward Monon and Chicago.

The following chemical analyses(83) are taken from the report by Cumings and Shrock.

(83)Cumings, E. R. and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Dept. of Conservation, State of Indiana, 1928, p.96.

	I	II	III	IV	V	VI	VII
CaCO3	54.80	53,12	55.80	54.28	95.82	53.36	56.00
MgCO3	43.10	44.69	45.67	44.18	0.86	44.60	43.00
SiO2	1.14	0.81	0.36	1.67	1.11	0.40	-----
Al2O3 and Fe2O3	0.52	0.83	0.50	0.95	0.58	1.70	-----
SO3	-----	0.03	-----	-----	0.52	-----	-----
Loss	-----	0.32	-----	-----	0.83	-----	-----
Total	99,56	99.80	102.33	101.08	99.72	100.06	99.00

I. Four and one-half miles west of Celina, Ohio (Orton and Pepple, 1906, p. 96.)
II. Ridgeville, Indiana (R. R. Shrock)
III. Portland, Indiana (30th Ind. Rept., p. 257.)
IV. Huntington, Indiana (30th Ind. Rept., p. 245.)
V. Georgetown, Indiana (H. Fletcher)
VI. Delphi, Indiana (30th Ind. Rept., p. 273.)
VII. Monon, Indiana (G. Balfe)

The sample No.V, from Georgetown, was from a reef and does not show the true dolomitic character of the Huntington.

The Huntington dolomite is the bedrock over a wide area in the Wabash Valley, though usually covered by glacial drift. It is quite porous at the contact with the drift and this horizon is water-bearing. Many public supplies come from this horizon, and many privately owned wells penetrate a few feet into the dolomite. The Huntington dolomite is saccharoidal and well cuttings indicate the formation is porous, however, the individual pores are not connected so that water can move freely. Reference has previously been made to the conditions at Fort Wayne.(84) There the Huntington dolomite was porous at the drift contact, but with depth became less porous and did not bear water. While this horizon is ordinarily an excellent aquifer the water table was lowered at Fort Wayne so much that it appeared impossible to obtain additional supplies for a growing population and for industrial needs.

(84) Shields, James L., Secretary, Fort Wayne Water Works. Personal communication, March 30, 1933.

Liston Creek limestone. -- The Liston Creek limestone is conformable with the overlying Huntington dolomite. It has been suggested by Cumings and Shrock that the Liston Creek correlates with the Louisville limestone of southern Indiana. Areally the Liston Creek outcrops over a broad area in Miami, Wabash, Huntington, Wells, Grant, Blackford, Madison, Hamilton and Delaware counties. It is from a few feet to as much as 80 feet in thickness. It consists of a series of alternating thin-bedded layers of chert and limestone. Subterranean drainage has developed in many outcrop areas of the Liston Creek. The base of this formation grades conformably into the underlying Mississinewa shale. Where conditions are favorable springs are common at the contact of the Mississinewa shale and the Liston Creek limestone.

Mississinewa shale. -- The Mississinewa shale is well expose along the Mississinewa and Wabash rivers in Miami, Wabash, Hunt- ington, and Grant counties. It does not outcrop throughout its entire vertical extent but is believed to include all the strata lying between the base of the Niagaran and the base of the Liston Creek limestone. The thickness ranges from 75 to 250 feet, thou only 75 feet are exposed on the outcrop.

Chemical analyses of the Mississinewa shale show that it is a calcareous shale or shaly limestone. The top of the Mississin- ewa shale is a spring horizon, where conditions are favorable for gravity springs. Because of the impervious character of the shale, the water, since it cannot penetrate the shale, flows laterally until an opening is reached. The clayey character of the Mississinewa shale prevents it from being an aquifer.

SILURIAN OF SOUTHERN INDIANA

Chart Showing Silurian Stratigraphic Units in Southern Indiana

System	Series	Correlation	Formation
Silurian	Niagaran	Waukesha	Louisville limestone Waldron shale Laurel limestone
		Rochester	Osgood formation
	Medinan	Cataract	Brassfield

The Silurian strata of southern Indiana outcrop or underli the drift in Rush, Fayette, Franklin, Decatur, Shelby, Bartholom Jennings, Ripley, Jefferson, and Clark counties. All of these counties with the exception of Clark have been mantled with Illinoian drift. Clark County is in part covered with Illinoia drift. (See Plate III of this report, for the Illinoian drift boundary.)

Louisville limestone. -- The type locality of the Louisvil limestone is just east of the city of Louisville in Kentucky. Indiana this formation is a light gray to yellowish or buff, massive, magnesian limestone. Its upper part is very fossili- ferous in the Louisville region, but north of Jefferson County, Indiana fossils are very rare. At the type locality the form- ation is 63 feet thick, but varies from 42 to 100 feet in Jeffe son County, Kentucky. Foerste (85) has stated that the Louisvi limesto

(85) Foerste, A. F., The Silurian of Southeastern Indiana, 28th Ann. Rept., Indiana Dept. of Geology and Natural Resources, 190 pp. 21-39.

thins from Louisville in a northward and eastward direction. T Louisville is overlain unconformably by the Devonian (Jefferson ville and Geneva limestones.) Since the

Louisville limestone is underlain by the Waldron shale or a shaly portion of the Laurel limestone, the formation is locally an aquifer. Joint and bedding planes are the sources of the water. Frequently wells are drilled through the overlying Jeffersonville and into the Louisville limestone without recognizing any break. The unconformity has created condition favorable for rendering the upper surface of the Louisville limestone porous.

Waldron shale.-- The Waldron shale lies below the Louisville limestone. It thickens from north to south, but in most areas is under ten feet in total thickness. Because of the impermeability of the clays and shales the Waldron is not an aquifer. Its main function is to prevent the escape of water from the Louisville limestone and cause artesian conditions to prevail in this latter formation. The Waldron is unconformable with the Louisville limestone.

Laurel limestone. -- The Laurel limestone or dolomite is an evenly bedded, white, hard rock from 40 to 50 feet thick. It usually occurs in well-bedded layers, and this has made it important locally as a quarry stone. It has been quarried in Fayette, Franklin, Rush, Decatur, Jennings, and Ripley counties. In Jefferson County, the formation is yellower in color, more argillaceous, and unfit for a quarry stone. Chert is frequently present, especially in the middle part of the formation. The Laurel has a fairly narrow outcrop belt. It contains some water in joint crevices. Springs that derive their waters from this horizon are locally important.

Osgood formation. -- The Osgood formation consists of two beds of shale and two beds of limestone. The entire section is 20 feet or less in thickness and because of the alternating series of limestones and shales is not considered of more than local importance in relation to ground water.

Brassfield limestone. -- The Brassfield formation is disconformably below the Osgood formation, and also disconformably above the Ordovician rocks. It consists of a coarsely crystalline, mottled pinkish limestone, varying from a foot or less to 15 feet in thickness. Foerste(86)

(86) Ibid., p. 27.

has described the Brassfield of southeastern Indiana as a detrital limestone. Owing to the small thickness of the Brassfield and its limited distribution, the ground water possibilities of this formation are insignificant, except locally where small springs issue from joints and crevices.

ORDOVICIAN SYSTEM

The Ordovician strata of Indiana are limited in areal extent to the southeastern portion of the State, chiefly south of Wayne County. They occupy all or a large part of Wayne, Union, Fayette, Franklin, Dearborn, Ripley, Ohio, Switzerland, and Jefferson counties, and small areas

in Decatur, Jennings, and Clark counties. Their entire areal extent is approximately 1800 square miles, and is the smallest of any of the great rock systems of Indiana.

The Ordovician rocks are the oldest in the State and the Trenton formation has been very productive of oil and gas in both Indiana and Ohio.

Ordovician strata come to the surface at a single locality in northwestern Indiana. Near Kentland, in Newton County the oldest Ordovician rocks exposed in the State outcrop in several small quarries and were probable brought to the surface by crypto-volcanic action.

For a complete history of the nomenclature and description of the Ordovician system of rocks, the reader is referred to the excellent summary by Cumings.(87)

(87) Cumings, E. R., Nomenclature and Description of the Geological Formation of Indiana, Part IV, Handbook of Indiana Geology, Publication No. 21., Dept. of Conservation, State of Indiana, 1922, pp. 416-42.

Chart Showing Stratigraphic Units of Ordovician of Indiana

System	Series	Correlation.	Formation
Ordovician	Cincinnatian	Richmond 250-270'	Elkhorn Whitewater Saluda Liberty Waynesville Arnheim
		Maysville 135-157'	Mt. Auburn Corryville Bellevue Fairmount Mt. Hope
		Eden 200-230'	McMicken Southgate Economy
	Mohawkian	Trentonn 350-600' Black-River-Lowville Stones River St. Peter	Cynthiana and other "Trenton" formations St. Peter

Cincinnatian Series. -- The Cincinnatian series unconformably underlies the Silurian (Brassfield) of Indiana. It is further subdivided in descending order into Richmond, Maysville and Eden. Each of these is further subdivided into lithologic and paleontologic units. The Richmond -

Maysville and Eden. Each of these is further subdivided into lithologic and paleontologic units. The Richmond consists of a succession of limestone layers intermixed with shale beds, the lower part being predominantly shale. The middle or Maysville member of the Cincinnatian series is chiefly composed of limestone. The basal or Eden member of the Cincinnatian series consists chiefly of shales. Thus the entire series is a succession of limestone and shale layers. This gives proper conditions for the occurrence of springs, provided the limestone layers are thick enough to have joints and crevices to contain water. There are very few springs in the area of the Cincinnatian rocks, except where overlain by glacial drift. Where streams have cut down through the strata of the Cincinnatian, seepage occurs, Small wells are developed in this area, but they do not develop much head. It is necessary for the residents of the region to depend on shallow wells and cisterns for water supplies.

Mohawkian Series. -- The Cynthiana member of the Trenton formations outcrops in a narrow belt between the towns of Florence and North's Landing along the Ohio River in Switzerland County. The bed is about 50 feet thick and consists of a dark blue to gray, well-bedded limestone. The buried Trenton formations contain oil and gas at various localities along the Cincinnati Arch. The upper part of the formation is frequently porous and dolomitized. Salt water is always fourd. Well borings which have gone through the entire Trenton, report thickness varying from 350 to 600 feet. The upper surface of the Trenton is unconformable with the overlying Cincinnati series.

Pre-Trenton formations. -- The pre-Trenton formations which underlie Indiana, with the one exception noted near Kentland, do not come to the surface. A study of cuttings from deep wells has enabled Logan (88) to draw some tentative conclusions concerning

(88) Logan, W. N., The Subsurface Strata of Indiana, Publication No. 108, Dept. of Conservation, State of Indiana, 1931 pp. 7-13.

the older Ordovician and Cambrian strata. As only a limited number of deep wells have penetrated the St. Peter sandstone it is not possible to state with authority the exact distribution of this formation.

"Wells at the following places have passed to or below the St. Peter formation of the Ordovician: East Chicago, Grasmere, Lacrosse, Bryant, Greentown, Greensburg, Middle Fork, Bloomington, Calvertsville, Cloverdale, Covington, Milltown, Lawrenceburg, Rising Sun, Brookville, Connersville, Richmond, Franklin, Portland, Delphi, Laporte, Highland and Indiana Harbor.

Wells which reached Cambrian formations are located at Bryant, Greentown, Greensburg, Middle Fork, and Cloverdale."

From the standpoint of ground water, the pre-Trenton formations are not important, due to the fact that in

practically every case they are highly mineralized. Possible exceptions to this statement are likely to occur in northwestern Indiana. Potable waters are obtained from the St. Peter sandstone, New Richmond and Jordan sandstones in northeastern Illinois, but increasing distance from the outcrop tends to produce high mineralization of the contained waters. The great depths at which these formations are found in Indiana prevents their practical use as aquifers. In southeastern Indiana the depth would not be excessive; however, the waters are unfit for use.

SUMMARY DESCRIPTIONS BY COUNTIES

A D A M S C O U N T Y

GENERAL FEATURES

Area 337 square miles Population 19,957 (Census of 1930)

Adams County is situated on the eastern border of the State, and is the fourth county south of the Michigan-Indiana State line. The county has a large amount of plane surface, although two moraines break the general monotony. One moraine is northeast of the St. Mary's River and the other is northeast of the Wabash River. The drainage is to the northwest, and the altitude of the southern portion of the county is approximately 100 feet greater than the northern portion. The maximum altitude in Adams County is 895 feet above sea level and the minimum is 760 feet above sea level, thus giving a total maximum relief of 135 feet. The maximum local relief is only 60 feet. Adams County lies entirely within the Tipton Till Plain and is drained for the most part by the St. Mary's and Wabash rivers and a few tributaries. Both streams flow northwestward across the county.

GEOLOGY

The present surface geology of Adams County is the record of sub-aerial erosion on Wisconsin drift. The glacial drift is as a rule thin, ranging from a few feet to more than one hundred feet in a few localities. Till is the predominant glacial deposit of the county and consists of a yellow stiff clay, occassionally intermixed with sand and boulders. Frequently thin beds of gravel occur just above the bedrock. These gravels are excellent aquifers and this particular horizon supplies much water within the county. The glacial drift, the valley alluvium along the two major streams, and very limited exposures of bedrock compose the surface of the county insofar as supplies of ground water are concerned. The valley flat deposits are locally of importance as sources of ground water. The bedrock strata of Adams County consists of rocks of Silurian (Niagaran) age. The entire county is masked with drift, though the Silurian limestones and dolomites have been quarried at four places in the county. In addition to these quarrying operations, Adams County has produced oil and gas for many years and the records of wells drilled within the county give an abundance of information on the sub-strata.

Adams County is on the northeastern slope of the Cincinnati geanticline, and the bedrock strata dip northeastward. The top of the Trenton formations is approximately 150 feet below sea level in the southwestern part of the county nd is 500 feet below sea level in the northeastern part.

Generalized Geologic Section for Adams County:

Quanternary:

Recent, -- sand, gravels, chiefly alluvial deposits . . . . . 0-25'

Pleistocene, -- glacial depostis . . . . . 10-110'

Silurian: limestones, dolomites, shales . . . 400-540'

Ordovician:

Cincinnatian, -- limestones and shales .. 700'

Mohawkian, -- (Trenton formations) . . . . 40'
(Not drilled through)

GROUND WATER

The wells of Adams County practically all draw their supply from the drift. The best waters occur in the glacial drift. Dug wells that draw their waters from the sandy and gravelly deposits in the drift are characteristic of the later drift, whereas drilled wells into the deeper and earlier drift generally penetrate to the base and rely on the gravelly and sandy layers that lie immediately above the bedrock.

Adams County is entirely underlain by rocks of Silurian age. Over a large area bedrock is from 35 to 50 feet below the surface. At Decatur, along the St. Mary's River, old quarries now filled with water furnished stone for both construction wo and lime burning. Rock is struck in the courthouse well at 40 feet. This well penetrated till, with the exception of a few feet of sand at the bottom. At Geneva, in the southern part of the county, a gas-well boring revealed 350 feet of drift. This is to be explained by valley excavation of a pre-glacial stream, since bedrock outcrops within a mile of the gas-well boring, and is found at almost the same elevation as the mouth of the well. This old-preglacial channel was referred to as the "Deep Drive" by oil well drillers because of the great length of drive pipe necessary before reaching bedrock. Adjacent to the "Deep Drive" the glacial drift is usually about 70 feet in thickness. The Silurian strata underlying the drif consists of dolomites, shales, and limestones. The dolomite immediately in contact with the drift is an old erosion surfac which accounts in part for the undulatory character of the bed rock and resulting discrepancies in thickness of the till. The eroded surface was subjected to all the agencies of weathering previous to the covering with till, so that the dolomite near the surface is an aquifer. In addition, rocks of this character show joint cracks and bedding planes along which ground water can flow. Many of the drilled water wells in Adams County penetrate a few feet into the Silurian strata to augment the water-supply occurring at the contact between the drift and the strata.

Along the St. Mary's and Wabash river bottoms, wells often reach water at a depth of twenty to thirty feet. A very few exposures of bedrock occur along the stream courses at or near water level, several having been described from the St. Mary's River. Where the streams are entrenched deeply into the glacial drift, it is likely that ground waters leave the drift and flow away as surface waters in the streams.

Water Supplies of Towns in Adams County

Berne. -- (population 1,883) Berne is supplied with water from four wells. The wells are eight inches in diameter and drilled to a depth of about 210 feet. The Silurian limestone was penetrated at 205 feet. Water stands in the wells at 60 feet below the curb. It is likely that the contact between the drift and the bedrock and the few upper feet of the Silurian limestone furnish the water. The local officials report that the supply fluctuates with the seasons; however, an adequate supply is maintained at all times.

Decatur. -- (population 5,156) Decatur has municipal water department which obtains a water-supply from eight wells drilled to a depth of 250 feet. Bedrock was penetrated at 35 feet and water in the wells rises to about this level. The city supply comes from the Silurian formation which immediately underlie the drift. Many private wells secure water at depths ranging from 30 to 50 feet in sands and gravels of the glacial drift.

Geneva. -- (population 895) Geneva reports a supply of water secured from one well, drilled 185 feet into glacial drift. Gravels were penetrated at this depth. Many wells in this community find good water at depths ranging from 35 to 80 feet into the gravels and sands of the drift.

It is interesting to note that only 8 per cent of the wells listed have soft water, though it is admitted that hardness and softness of water are relative terms which mean different degrees of hardness to different people.

Typical Wells of Adams County

Location	Depth	Quality	Quantity	Formation	Constructi
T25N-R14E					
Sec. 4	100'	Hard	Good	Limestone	Drilled
Sec. 29	142	"	"	Gravel	"
T25N-R13E					
Sec.2-3	65	"	"	Limestone	"
Sec. 11	50	"	"	"	"
Sec. 25	66	"	"	"	"
T26N-R14E					
Sec. 4	80-200	"	"	"	"
Sec. 33	125-300	"	"	Ls and Gravel	"
T26N-R13E					
Sec. 2	200	"	"	Limestone	"
Sec. 23	60	"	"	"	Driven
T27N-R14E					
Sec. 21	100	"	"	"	Drilled
T27N-R13E					
Sec. 11	70	"	"	Gravel	"
Sec. 13	50	"	"	"	"
T28N-R13E					
Sec. 24	75-125	"	"	Limestone	"
Sec. 35	80-180	"	"	"	"
T28N-R14E					
Sec. 18	80	"	"	"	"
T25N-R14E					
Sec. 34	82	"	"	Gravel	"
Sec. 25	80	"	"	Limestone	"
T25N-R15E					
Sec. 14	100	"	"	"	"
Sec. 36	60	"	"	Gravel	"
T26N-R15E					
Sec. 25	30	Soft	"	"	Dug
T26N-R14E					
Sec. 23	40	"	"	"	Driven
Sec. 24	100	Hard	"	"	Drilled
T27N-R15E					
Sec. 35	60	"	"	Limestone	"
Sec. 8	220	"	"	"	"
Sec. 20	50	"	"	"	"

A L L E N C O U N T Y

GENERAL FEATURES

Area 661 square miles Population 146,743 (Census of 1930)

Allen County is located in the northeastern part of the State, bordering the State of Ohio. It is the third county south from the Michigan-Indiana State line. Fort Wayne is the county seat. This county has the distinction of being the largest in area and the fourth in population in Indiana.

The greater part of Allen County is fairly level, although two well-defined morainic belts cross the county. The Ft. Wayne moraine enters the county near the northeastern corner and trends southwestward to Ft. Wayne and thence southeastward. The Wabash moraine parallels the former and trends southwestward to the southwestern corner of Allen County, then turns southeastward. The eastern part of the county was formerly covered by a glacial lake which discharged southwestward to the Wabash River. This portion of the county is very smooth with only a few lake bars of sand and gravel to interrupt the general level surface of the old Lake Maumee bottom. Artificial drainage has aided in reclaiming this area for agricultural purposes.

The southern third of Allen County is included in the Tipton Till Plain. The northwestern third is a part of the Steuben Morainal Lake Section. The eastern third has already been described as the Maumee Lacustrine Plain. These various subdivisions and a full discussion of the physiography of northeastern Indiana have been discussed by Malott. (89)

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(89)
Malott, C. A., Physiography of Indiana, Handbook of Indiana Geology, Publication 21, Department of Conservation, State of Indiana, 1922, pp. 61-256.

The maximum altitude in Allen County is 925 feet above sea level and the minimum is 705 feet above sea level, thus giving a total relief of 220 feet. The maximum local relief is approximately 100 feet.

Allen County is located for the most part in the Maumee drainage area of Indiana. The western one-fourth of the county lies within the Wabash drainage area. The Maumee River, which is formed by the confluence of the St. Joseph River and the St. Mary's River, flows from Ft. Wayne northeastward through Allen County into Ohio where it ultimately discharges into Maumee Bay on Lake Erie. The St. Joseph River enters Allen County on the north from DeKalb County and with its tributaries drains the north-central portion of the county, while the St. Mary's entering from Adams County on the south drains the south-central portion of the county. The northwestern part of the county is drained by Eel River, a branch of the Wabash River, and the

southwestern portion is drained by the Little Wabash and its tributaries. Allen County has been pointed out as a watershed, part of whose waters discharge through the Maumee, the Great Lakes, and the St. Lawrence into the Atlantic, and the rest through the Wabash, Ohio, and Mississippi into the Gulf of Mexico.

GEOLOGY

The unconsolidated deposits of Allen County consist of till, lacustrine beds and alluvial deposits along streams. In the southern half of the county the thickness of the glacial drift averages about 75 feet and in the northern half of the county it is much thicker. Near the north border well records show a thickness of 200 feet of drift, but near the south border a few wells penetrate bedrock at 30 feet or less. The glacial drift is a compact till intermixed with sand and gravel, with the coarser materials usually near the base and bearing plentiful ground water. Well records show that the pre-Pleistocene erosion trenched deeply the surface of the bedrock which produces a great variation in the thickness of the drift.

The lacustrine deposits of the Maumee area extend into Indiana from Ohio, with the apex near Ft. Wayne. About 120 square miles of these lacustrine sediments occur in Allen County, and have been described by Dryer (90) in detail.

(90) Dryer, Charles R., Geology of Allen County, 16th Ann. Rept., Indiana Dept. Geology and Natural History, 1888, pp. 107-14.

The following log is given of a well located in the Maumee Lacustrine Plain.

Yellow clay	7'
Blue clay with gravel	20'
"Putty clay"	5'
Quicksand	1'
Water-Bearing gravel	3'

At one time flowing water occurred at depths between 35 and 45 feet, the water coming from the higher morainal ground.

The alluvial deposits of Allen County are local in extent. The present Maumee River is deeply entrenched below the plain and has little or no valley flat. Local deposits are found along the St. Joseph and the St. Mary's rivers. Old drainage channels contain fluvio-glacial materials which contain ground water at the present time. The Wabash-Erie channel is the best example, extending from Ft. Wayne southwestward toward Huntington County. At New Haven deposits of sand occur which are believed to represent an old delta made at the mouth of the St. Mary's River when it flowed into Lake Maumee. It is readily seen that a close connection exists between the glacial deposits and those made by flowing water, since melting ice fed the streams.

No outcrops of bedrock are found within Allen County. From a study of well records it is known that the northern part of the county is underlaid by rocks of Devonian age, while those in southern part are Silurian (Niagaran). Dr. Richard Owen (91)

(91) Owen, Richard, Geological Reconnaissance of Indiana, 1859-60, State of Indiana, p. 215.

described rocks from Allen County, located in Section 35, Township 30 North, Range 13 East, some eight miles southeast of Ft. Wayne. He correlated the rocks as either Devonian or Silurian. In 1888 this same area was visited by Dr. Charles R. Dryer; however, at this date only fragments of limestone embedded in mud were found.

In 1929 the Ft. Wayne Water Works drilled two test holes in the southwestern part of that city and a complete set of the cuttings were studied by Dr. E. R. Cumings. (92)

(92) Cumings, E. R., Silurian Studies, Proc. Ind. Acad. Sci., Vol. 39, 1929 (1930). pp. 183-99.

The following is the record of well #1, located near the corner of Ardmore Avenue and South Street, as given by Dr. Cumings:

Surface elevation	755.2' A. T.
Glacial drift	0-110'
Thin remnant of Greenfield dolomite .	
Huntington dolomite, upper portion . .	110-280'
New Corydon dolomite	280-380'
Huntington dolomite, lower portion . .	380-560'
Liston Creek limestone	560-640'
Total depth	640'

This well had a total thickness of 530 feet of Niagaran strata.

A second well drilled by the same company and cuttings of which were studied by Dr. Cumings is believed to have penetrated the Liston Creek limestone for 75 feet and then to have gone into the top of the Mississinewa shale, the next underlying formation, which is also Niagaran in age.

A study of Dr. Cumings' work reveals the character of the bedrock at Ft. Wayne. One is impressed with the imporosity of the strata, especially the Mississinewa shale. The dolomites above this shale contain ground water and had been the source of supply for the city of Ft. Wayne, together with the glacial drift for over fifty years. The test wells (93) showed that additional supplies could not be obtained by drilling, that the new wells

(93) Shields, James L., Secretary, Forth Wayne Water Works, Private communication to author.

caused the old wells to be lowered and that Ft. Wayne was experiencing a gradual lowering of the water horizon in the wells.

These facts coupled with an increasing population and industrial expansion were the basis for shifting from the use of ground water supplies to a river reservoir supply.

Many wells in Allen County have been drilled to the Trenton limestones of the Ordovician in the search for oil and gas. Data based on the upper surface of the Trenton limestone show this formation to be approximately 300 feet below sea level in the southwestern corner of the county, and in the northeastern corner the same stratum is approximately 900 feet below sea level.

Generalized Geologic Section for Allen County:

Quaternary:

Recent, -- alluvial deposits	0- 10'
Pleistocene, -- glacial deposits	30-300'
Devonian: black shale, limestone	10-140'
Silurian: limestone, dolomite, shale	530-575'
Ordovician:	
Cincinnatian, -- shales and limestones . .	700-750'
Mohawkian, -- (Trenton formations)	255'

GROUND WATERS

The most important water horizons in Allen County are the sand and gravel lenses associated with glacial drift. Even the till will supply water slowly. The drift over the county will average 100 feet in thickness. Wells in the southern part of the county penetrate solid rock at a shallower depth than those in the northern part, hence reach sand and gravels bearing water earlier. The local surface expression of the small areas may be the determining factor in arriving at the total depth to ground water. Wells located on ridges of morainic material, on kames and other topographically high areas would usually find it necessary to go somewhat deeper in the search for water than wells adjacent in stream valleys or other low areas.

In the Maumee Lake region of the eastern part of the county the surface soil is a compact boulder clay, overlaid in some places by laminated clays and occasionally a patch of sand and gravel. The surface clay is usually yellow, though becomes blue with depth. Wells drilled in the Maumee Lacustrine Plain occasionally strike a pocket or layer of sand and gravel which produces water abundantly. Along the northwestern borders of the old lake floor are "fountain wells" described by Dr. Charles R. Dryer as follows:

> "Near the line between Springfield and Milan and Maumee Townships, there are as many as twenty springs within a distance of three miles. Flowing water is usually struck at depths between 35 and 45 feet and a copious stream rises to the surface, or a few feet above.

In the last few decades the water table has been distinctly lowered in this county. Springs have ceased to flow, also flowing wells have ceased. In the city of Ft. Wayne, flowing wells existed until 1905. These wells at the present time do not flow, and reference has already been made to the lowering of the water table from which the city supply was derived. It is reported that water stands at depths from 18 to 60 feet below the surface in many wells in the city.

A well drilled in the courthouse yard at Ft. Wayne in 1875 reached a depth of 3000 feet. The glacial drift was 88 feet in thickness and water rose to within a few feet of the curb. Due to the fact that the temperature of the water was so nearly the same as that of water from the drift, it was concluded that the water came from near the surface and not from deeper horizons.

A well sunk for gas in 1888 and known as the Abbott well, located two miles southeast of the courthouse was drilled to a depth of 1900 feet. Mineralized water was found in the Trenton limestones and rose in the well to within 900 feet of the surface. Many wells drilled into the Trenton formations in search for oil and gas found salt water in the Trenton.

Water Supplies of Towns in Allen County

Fort Wayne. -- (population 114,946) The city of Fort Wayne has a municipal water department which for several years has obtained a supply from 51 wells. Some of the wells produce from the gravels and till which are about 70 to 110 feet in thickness, while other wells produce from the Silurian limestones and dolomites which underlie the drift. Wells in the bedrock are 250 to 450 feet in depth. At the present time the city of Fort Wayne has under construction a new water system which will secure water from the St. Joseph River. Two dams will impound the water. It is estimated that sufficient water will be obtainable to supply a city whose population is five times that of the present city. A modern purification and softening plant will give this city a most modern water plant. A diminishing supply from the rock wells with no good prospects of securing additional ground water supplies plus the further fact that Fort Wayne is rapidly expanding were the determining factors in favor of the change to the reservoir system.

New Haven. -- (population 1,702) The town of New Haven reports a water supply from two wells. Bedrock was struck at 62 feet. At 150 feet a good flow of water was obtained, which rose nearly to the surface. At 300 feet additional water was penetrated which increased the head to 11 feet above the surface. It is reported to stand three feet below the curb at the present time. A few artesian wells are reported in the community. Private wells find water at a depth of 30 feet, though wells drill through 60 to 70 feet of till.

Typical wells of Allen County

Location	Depth	Quality	Quantity	Formation	Construction
T29N-R13E					
SW¼ Sec. 29	40-60'	Hard	Good	Limestone	Drilled
T29N-R12E					
NW¼ Sec. 13	40	"	"	Gravel	Dug
T30N-R12E					
SW¼ Sec. 26	125	"	"	Limestone	Drilled
T30N-R13E					
Sec. 10	263	"	"	"	"
NW¼ Sec. 22	100	"	"	Gravel	"
NE¼ Sec. 22	235	"	"	Limestone	"
T32N-R11E					
SE¼ Sec. 18	16-25	"	"	Gravel	Driven
SW¼ Sec. 29	80	"	"	Limestone	Drilled
T31N-R11E					
SE¼ Sec. 11	65	"	"	Gravel	"
SE¼ Sec. 26	35	"	"	Sand	Driven
T32N-R11E					
SW¼ Sec. 26	85	"	"	Gravel	Drilled
T30N-R11E					
SW¼ Sec. 3	70	"	"	Limestone	"
NW¼ Sec. 21	100	"	"	Gravel	"
T29N-R11E					
NW¼ Sec. 5	40	"	"		"
NE¼ Sec. 17	140	"	Medium	Limestone	"
SW¼ Sec. 22	80	"	Good	"	"
T29N-R13E					
NW¼ Sec. 8	114	"	"	Gravel	"
NE¼ Sec. 8	100	"	"	"	"
T29N-R14E					
SW¼ Sec. 9	53	Soft	"	"	Dug
SW¼ Sec. 11	30	"	"	"	"
Sec. 11	110	Hard	"	Limestone	Drilled
T30N-R15E					
SW¼ Sec. 19	35-100	"	"	Gravel	"
SE¼ Sec. 1	72	"	"	Limestone	"
T30N-R14E					
Sec. 1	80	"	"	"	"
T31N-R15E					
NW¼ Sec. 30	62-120	"	"	"	"
SE¼ Sec. 30	72-80	"	"	"	Drilled (60' to Ls)
SW¼ Sec. 7	30-42	Soft	"	Gravel	Dug
T31N-R13E					
NE¼ Sec. 6	97	"	"	Sand	Drilled
NE¼ Sec. 6	200	Hard	"	Limestone	"
Sec. 6	18	Soft	Fair	Sand	"
Sec. 6	72	Hard	Good	Limestone	"

B A R T H O L O M E W C O U N T Y

GENERAL FEATURES

Area 407 square miles Population 24,864 (Census of 1930)

Bartholomew County is located in southeastern Indiana, the third county northwest from the Kentucky- Indiana State line, and the fourth county west from the Ohio-Indiana State line. The county lies wholly within the drainage basin of the East Fork of White River. The entire county was invaded by the Illinoian glacier, but the western hilly section bears little evidence of glaciation. The outermost limit of the Wisconsin drift crosses this county, passing near the northwestern corner to to the northwestern corner of Jennings County. Monainal topography is found in the area of Wisconsin drift. The maximum altitude in Bartholomew County is 1000 feet above sea level and the minimum is 555 feet above sea level, thus giving a total maximum relief of 445 feet. The maximum local relief is 300 feet. Portionsof the Muscatatuck Regional Slope, the Scottsburg Lowland and the Norman Upland lie in the county. The Norman Upland area in the western part of the county is the region of greatest relief. The Scottsburg Lowland in the middle section of the county is best represented by the White River valley plain. The eastern section of the county rises gently eastward into the Mascatatuck Regional Slope. The main stream of the county is the East Fork of White River which passes somewhat centrally through the county from north to south. The Knobstone Escarpment, separating the Scottsburg Lowlard from the Norman Upland, stards out boldly through much of the county from north to south, west of the broad White River valley.

Geology.

The unconsolrdated deposits of Bartholomew County consist of glacial drift and alluvial stream deposits. The glacial drift varies in thickness from a few feet to more than 100 feet. The surface of the older drift is generally best represented in rather extensive level plains, though in places considerable dissection has taken place. The younger drift is morainic with the till some thirty to forty feet below the tops of the hills of drift. Along the East White River valley there is a gravelly belt from two to five miles or more in width. This river valley has morainic krolls from the north boundary of the county as far south as Columbus. Flat Rock valley contains a broad gravel plain. In the remainder of the county the drift is mainly till. Ground water occurs abundantly in the gravel deposits along the streams, also in the morainal deposits and in sard ard gravel of the till. The valley train which borders White River is especially noted for ground water. Very few deep wells occur. A border of low dune hills extends southward from Columbus on the east flank of the White River valley.

The bedrock formations of the eastern part of the county are of Silurian and Middle Devonian age. Silurian strata outcrop

only along Clifty Creek west of Hartsville. They are exposed by the downward cutting of Clifty Creek. This area is noted for the occurrence of the inlier of Silurian strata.

A wide belt extending north and south through the middle part of the county is underlain by the Upper Devonian, New Albany shale consisting primarily of black shales. This outcrop belt corresponds in part to the Scottsburg Lowland physiographic unit. This belt of black shale which underlies the drift is not an aquifer, hence the drift must supply the water or deeper wells must be used. The valley train along White River is locally a source of water supply over a portion of the shale outcrop belt.

The western one-fourth of Bartholomew County, which is unglaciated and corresponds to the Norman Upland area physiographically, is underlain by Mississippian strata. These rocks belong to the Borden series and are composed of shales, sandstones and siltstones. The Borden strata contain only small supplies of water and are not considered as aquifers.

The bedrock formations of the county dip to the southwestward. Well records indicate that the surface of the Trenton limestone lies at an elevation of 100 feet below sea level in the northeastern part of the county and the same horizon is found at an elevation of 600 feet below sea level in the southwestern part of the county. Water-bearing horizons in the bedrock formations will be encountered at increasing depths from the northeast corner toward the southwest corner of the county, with increasing depths at greater surface elevations.

Generalized Geologic Section for Bartholomew County:

Quaternary;

Recent, -- sands, gravels, chiefly alluvial deposits . . . . . 0-50'

Pleistocene, -- glacial deposits. . . . . 0-100'

Mississippian:

Borden, -- shales, siltstones, sandstones . . . . . 0-450'

Rockford, -- limestone . . . . . 0- 5'

Devonian:

New Albany, -- shales . . . . . 0-125'

Middle Devonian limestones . . . . . 40-65'

Silurian:

Niagaran, -- limestones (only upper part exposed) 90-120'

Medinan, --

Ordovician: (not exposed)

Cincinnatian, -- limestones and shales:

Richmond . . . . . .

Maysville. . . . . 700-800'

Eden . . . . . .

Mohawkian:

Trenton, -- chiefly limestone and dolomite, penetrated only a few feet.

Ground Water

The water found in the glacial till constitutes the most important source of ground water in Bartholomew County. The depth ranges from 20 to 100 feet. The valley train along White River is the next important source. Near Jonesville wells obtain water at 20 to 30 feet, which is about the level of White River. On the low lands west of White River wells usually penetrate eight or ten feet of pebbleless clay, beneath which they enter till and water occurs in gravels associated with the till. At Columbus wells show different thicknesses of the glacial drift, ranging from 20 to 100 feet. Near the western border of the county on a prominent ridge underlain by Borden strata, a well record from Sec. 18, T. 9 N., R. 5 E., shows a surface mantle of 38 feet of drift. In the western portion of the county many wells record only 15 to 20 feet of drift. In the eastern part of the county the drift is approximately 40 feet thick before bedrock is penetrated. On the gravel plain along Flat Rock Creek, in the north part of the county, wells are usually obtained from ten to 20 feet, or about the level of the stream.

The Silurian strata which outcrop in the central-eastern portion of the county are water-bearing. They occur at greater depths westward across the county. These strata consist of limestones and dolomites, which bear water in joints and along bedding planes. The shale horizons act as impervious layers and assist in making proper conditions for artesian waters. When not too far removed from the outcrop or from the point where the glacial drift immediately overlies the Niagaran strata, potable waters occur, though at distances from these points the waters are liable to be mineralized and unfit for use.

The Devonian limestones which occur below the glacial drift in the eastern part of Bartholomew County are water-bearing. The occurrence of water is similar to that in the Silurian formations.

The New Albany black shales occur below the drift in this county and their width is approximately twelve miles, which is over one-half of the county. This shale horizon is not water-bearing and unless wells obtain water in the overlying drift, they

must be continued into the underlying Devonian limestones.

The Borden group of formations of the Mississippian are fou in most of the area west of White River. The contact of the drif with this formation is an excellent spring horizon and well horiz though the Borden cannot be depended upon for more than slow seep ing supplies. The Rockford formation, which is the basal Mississ ippian in Indiana is very thin in this county. It ranges from a very few inches to as much as five feet in thickness. Outcrops are rare and due to the thinness of the limestone and the fact th the overlying Borden frequently bears salt water, the Rockford is not considered an aquifer.

Streams, wells, springs, and artificial reservoirs are the sources of water used for domestic, farm, industrial and public supplies in Bartholomew County. The alluvial deposits along White River may be used for local supplies. Deep wells in this county are likely to bear mineralized waters.

Water Supplies of Towns in Bartholomew County

Columbus. -- (population 9,935) The city of Columbus obtai a supply of water from the East Fork of White River. The plant is city owned and is described as complete with coagulation, sed- mentation, filtration and chlorination facilities.

B E N T O N C O U N T Y

GENERAL FEATURES

Area 408 square miles Population 11,886 (Census of 1930)

Benton County is located in northwestern Indiana adjacent to the State of Illinois and the third county south of Lake Michigan. Fowler is the county-seat. The county is occupied by several prominent drift ridges. In the north tier of townships a drift ridge, scarcely a mile in average width rises 25 to 75 feet above the general plain and passes entirely across the county. In the center tier of townships a prominent ridge enters from the Illinois side and trends northeastward in the vicinity of Fowler, where it terminates. This ridge has a width of three or four miles and a relief of 60 to 70 feet. In the south tier of townships occurs a third ridge, some three to four miles in width but with less relief. This ridge trends eastward to Oxford and then swings north and ends east of Fowler. Also northeast from Fowler are found a series of sharp drift knolls, 25 to 50 feet in height, filling a portion of the plain between the north and middle ridges. For the most part the general elevation of the county is fairly uniform. The maximum altitude in Benton County is 857 feet above sea level and the minimum is 630 feet above sea level, thus giving a total maximum relief of 227 feet. The maximum local relief is 70 feet.

The western and northwestern portions of Benton County are drained by streams leading northward into the Iroquois River, which is a tributary of the Kankakee River. The southern and central portions of the county are drained by streams which lead to the Wabash River. The most important stream is Pine Creek, which drains most of the eastern part of the County.

GEOLOGY

The Wisconsin till sheet covers all of Benton County. The drift material is made up of sand, gravel, clay and boulders and was deposited on the uneven surface of bedrock. The glacial drift ranges in thickness from a few feet to 260 feet or more. In the northern portion of the county the drift has been reported 300 to 400 feet in thickness. The deposits of alluvium along the streams are relatively insignificant as sources of ground water, hence are not considered.

Outcrops of bedrock are scarce in Benton County and occur

in a few isolated spots in old quarries along creek valleys. According to Logan (94)the bedrock strats underlying Benton County

(94)
Logan, W. N. et al., Geological Map of Indiana, Publication 112, Department of Conservation, State of Indiana, 1932.

consist of Devonian, Mississippian and Pennsylvanian formations. The Devorian black shales have been reported in a few wells in the northwestern part of the county and some 35 square miles in the southwestern part of the county appear to be urderlain by Pennsylvanian strata. The remainder of the county is urderlain by Mississippian strata belonging to the Borden group. The rock exposures mertioned previously occur in the dredged channel of Pine Creek in Pine Township, Section 24, and are of Mississippian age.

The bedrock strata of Benton County are not aquifers, with the possible exception of the Pennsylvanian. Due to limited area urderlain by the Pennsylvanian and also due to our limited knowledge of this group of rocks in northwestern Indiana, little can be known concerning their water-bearing possibilities. The glacial drift conceals the bedrock. It is definitely krown that the Devonian black shales will not contain water. It is possible to drill into the limestones and dolomites of the Devonian and Silurian, which are found at still greater depths, to secure water The Mississippian (Borden group) strata which underlie this county are not aquifers and will not supply ground water in sufficient quantities. Bentor County is fortunate in having such an excellent mantle of drift and it is not necessary to rely on wells drilled into the bedrock. Wells drilled into the Silurian and Devonian limestones should secure potable supplies of water.

General Geologic Section for Bentor County

Quaternary:

Recent, -- sands, gravels, chiefly alluvial deposits. .0- 30'
Pleistocene, -- glacial deposits. . . . . .
Pennsylvanian: (No exposures known)
Pottsville and Allegbery, -- shales and sandstones . 0-400'
Mississippian: (Few Exposures)
Borden, -- shales, siltstones, sandstones . . . . . .0-150'
Devonian: (No exposures known)
New Albary, -- dark shales . . . . . .
Limestones . . . . . .
Silurian: (Not exposed)
Limestones, dolomites, shales . . . . . .
Ordovician: (Not exposed)
Richmond, -- shales, limestones . . . . . .
Maysville, -- . . . . . .
Eden, -- . . . . . .
Trenton, -- limestones . . . . . .

GROUND WATER

With few exceptions the well water of Benton County is obtained from the glacial drift. Lenses of gravel occur in the glacial drift from which most of the water is secured. In some places sand and clayey till supply water, though the latter usually in small amounts.

The geological occurrence of ground water in this county has already been discussed. The contact between bedrock and the glacial drift is an excellent source of water. A few wells are drilled a few feet into the bedrock, though it is believed that the source of the water is the till. Several artesian wells have been reported in the county. A study of the typical wells of the county indicates considerable variation in depth. Well owners report considerable variation in the quantity and quality of waters obtained. These facts indicate further that the water-bearing beds lie not only at different depths but also in comparatively narrow belts rather than in widely extended sheets. Two wells in the same section and owned by the same individual range in depth from 42 to 112 feet. Wells so variable are undoubtedly supplied by distinct reservoirs which are not continuous but thin out within short distances. The fact, though, that some of the wells have sufficient head to flow abundantly at the surface, or even that water rises so near the surface indicates that the beds are not truly lens-shaped but extend for considerable distances in some direction. This direction is probably that parallel to the ice front on its advance and retreat or in a general upward direction.

It is interesting to note that Benton County was in large part original prairie land. This prairie belt joined the vast Illinois prairie belt and no particular relation is seen with the subject of ground water.

Typical Wells of Benton County

Township	Owner of well	Quality	Quanity	Depth	Formation
Bolivar					
SW¼ 15-24-7	Chas. Michael	Hard	Plenty	22'	Sand
NW¼ 24-24-7	John P. Grady	"	"	40	Gravel
SW¼ 18-24-6	E. Walters	"	"	52	Gravel
SW¼ 18-24-6	E. Walters	"	Limited	30	Gravel
SW¼ 17-24-6	J. P. Connelly	"	Plenty	40	Gravel
SW¼ 18-24-6	J. W. Moon	"	"	37	———
Centre					
SW¼ 9-25-8	Robert Brunn	"	"	36	Gravel
SE¼ 8-25-8	Robert Levelle	Medium	"	190	Gravel
SE¼ 7-25-8	Frank Leburge	Hard	"	72	Rock
SW¼ 12-25-9	Geo. Gretencort	Soft	"	100	———
NW¼ 16-25-7	F. E. Comes	Hard	"	400	Limestone
NW¼ 16-25-7	F. E. Comes	Very hard	"	32	Gravel
NW¼ 17-25-7	M. J. Cyr	Hard	"	65	Gravel
SW¼ 7-25-7	Joe Holscher	"	"	35.40	———
SW¼ 12-25-8	C. A. Gick	"	"	72	Soapstone
NE¼ 14-25-8	T. Johnson	"	"	36	———
Gilboa					
NW¼ 15-26-7	Geo. Howard	"	"	188	———
SE¼ 16-26-6	H. Waibel	"	"	100	———
SE¼ 17-26-6	S. Widemer	Soft	"	34	Gravel
NW¼ 20-26-6	EE. Bash	"	"	34½	Gravel
NW¼ 19-26-6	Otis Stanfield	Hard	"	74	Gravel
NE¼ 23-26-7	J. Morrison	"	"	65	Gravel
SE¼ 15-26-7	B. Nelson	"	"	40	Gravel

Typical Wells of Benton County (Continued)

Township	Owner of well	Quality	Quantity	Depth	Formation
Grant					
NE¼ 22-24-9	Robert Brown	Hard	Plenty	____	_____
SW¼ 14-24-9	Albert Fix	"	"	____	_____
SE¼ 13-24-9	Willis Clark	"	"	45	_____
SW¼ 17-24-8	W. R. Heneman	"	"	42	Gravel
S½ 17-24-8	W. R. Heneman	"	"	112	Sand
NE¼ 21-24-8	P. O. Chase	"	"	25	Gravel
Hickory					
NW¼ 23-24-10	P. Blakney	"	"	43	_____
SW¼ 13-24-10	L. Metzsinger	"	"	100	_____
SW¼ 18-24-9	J. Lenck	"	"	90	Gravel
SW¼ 18-24-9	J. Lenck	Soft	"	30	Sand
NW¼ 21-24-9	J. J. Schlinder	Hard	"	112	Gravel
Oak Grove					
S½ 15-24-8	C. Hibbs	Hard	"	100	_____
SE¼ 14-24-8	Ann Hendricks	"	Limited	60	Sand
NW¼ 24-24-8	A. Harfess	____	____	30	_____
Oxford	Municipal	____	____	95, 100	_____
Oxford	Municipal	____	____	101, 151	_____
SE¼ 16-24-7	Ralph Evans	Hard	Plenty	55	_____
Parish Grove					
NE¼ 14-24-9	Frank Worthington	"	"	____	_____
NW¼ 15-25-9	Dave Worthington	"	"	____	_____
NW¼ 16-26-9	Station at Free	"	"	80	Sand
NW¼ 16-26-9	Elevator at Free	"	"	60	"
NW¼ 8-25-9	Wm. Gretencourt	"	"	45	Gravel
NW¼ 18-25-9	J. Handy	"	Limited	80	_____
NE¼ 13-25-10	T. J. Salmon	"	Plenty	51	Gravel
SW¼ 11-25-10	Karl Schwartz	"	"	96	(11' ls.)
Freeland Park	_____	"	"	90 -100	Gravel

Townshpi	Owner of well	Quality	Quantity	Depth	Formation
Pine					
N½ 17-25-6	P. Comeright	Hard	Plenty	40'	———
SE¼ 7-25-6	Chas Martott	"	"	35	———
SW¼ 7-25-6	A. Nelson	"	"	70	Gravel
NW¼ 13-25-7	Geo. Smeltzer	Soft	"	———	———
NW¼ 14-25-7	John Beltch	Hard	"	200	———
SW¼ 11-25-7	Chas. Larson	"	"	———	———
Richland					
SW¼ 16-26-8	Chas. Leburg	"	"	———	———
SE¼ 17-26-8	R. Wetzel	"	Limited	60	Gravel
NW¼ 17-26-8	Chas. Weller	Soft	Plenty	122	Rock
SW¼ 18-26-8	Ray Lewellen	Hard	"	160	———
NE¼ 24-26-9	Walter Lohman	"	"	108	Rock
Earl Park	E. S. Yeager	"	"	88	Limestone
SE¼ 22-26-9	L. Denwiddle	"	"	———	———
Union					
SE¼ 1-26-8	John Pothing	Sulphur gas	"	95	———
NE¼ 12-26-8	John Pothing	Hard	"	50	Rock
NE¼ 21-26-7	L. Johnston	"	Limited	313	"
SW¼ 17-26-7	E. McDaniel	"	Plenty	90	"
NE¼ 24-26-8	P. O. Wadena	Medium	"	40	———
NW¼ 22-26-8	H. C Lust	Hard	"	———	———
SW¼ 14-26-8	R. Broulette	"	"	———	———
York					
SE¼ 21-26-9	M. Lawson	"	Limited	20	———
NW¼ 28-26-9	Geo. Dufrasne	Medium	Plenty	———	———
NW¼ 29-26-9	M. Bruce	Hard	"		Black sand
NE¼ 30-26-9	Joe Vaughn	Soft	"	———	———
SE¼ 24-26-10	E. Childress	Medium	"	96	Rock
NE¼ 26-26-10	Roy Yates	Hard	"	87	Gravel
NE¼ 26-26-10	Roy Yates	"	"	91	Gravel

Water Supplies of Towns in Benton County

Boswell. -- (population 817) The town of Boswell has obtained water from two wells. Records show bedrock penetrated at 320 feet and water came to within 80 feet of the surface. This water came from the glacial drift or Borden formations. The wells supplied 75,000 gallons per day. This yield indicates that the water probably came from the Borden. Late information in 1933 indicates that the town is drilling for additional supplies, though no data were reported about the well drilled.

Earl Park. -- (population 501) The town of Earl Park reports a water-supply from four wells which produce from the underlying limestone at a depth of 60 feet. Earl Park is six miles south of Kentland, and some peculiar structure in that region has brought Ordovician rocks to the surface. Present knowledge of this region indicates that Earl Park is underlain by Mississippian (Borden group) strata. It is probable that the water from Earl Park's wells comes from the drift or the more porous parts of the upper portion of the bedrock. Due to the mantle of drift in this region and the scarcity of good well records from which to study the geological section, the exact water horizon cannot be determined.

Fowler. -- (population 1,564) Fowler obtains a municipal water supply from six wells. Bedrock is reported at 150 feet. The wells are 874 feet, 700 feet, 118 feet and 417 feet in depth. One well produces from the glacial drift. In the absence of the records of the other three wells the geological age of the water-bearing formations cannot be determined.

Otterbein. -- (population 616) The town of Otterbein receives its supply of water from two wells drilled into the glacial drift. No records were available on these two wells. A private well in Otterbein reports a depth of 212 feet, with bedrock penetrated at 132 feet.

Oxford. -- (population 853) Oxford has four wells which produce water from the gravels at an unknown depth. Water stands at 16 feet below the curb. The water has a distinct taste of iron.

B L A C K F O R D C O U N T Y

GENERAL FEATURES

rea 168 square miles Population 13,617 (Census of 1930)

Blackford County is located east of the north-central part of the State. It is the fifth county south of the Michigan-Indiana State line and the second county west of the Ohio-Indiana State line. This county is small in area, having the distinction of being the fourth smallest county in Indiana. The three counties still smaller in area are Union, Floyd and Ohio.

The topography of the county is quite uniformly level except in the southwestern and northeastern portions. The southwestern half of the county is crossed by a moraine, and the extreme northeastern corner is crossed by a moraine. The remainder of the county is a plain area. The morainal belts are irregular and undulating in surface expression, however, there are no conspicuous hills. The average elevation of the county is about 275 feet above sea level, and the maximum local relief will not exceed 60 feet.

The Salamonie River and Lick Creek are the two principal streams in the county. The Salamonie River drains the northeastern portion of the county and the Lick Creek flows southwestward from near the center of the eastern county boundary. The Salamonie River flows northwestward across the north eastern corner of this county.

GEOLOGY

The surficial covering of Blackford County consists of glacial drift. The drift varies in thickness from 15 to 175 feet. At Montpelier, in the northeastern part of the county, wells are often drilled into the underlying Silurian limestone, though usually obtain water at the base of the glacial drift, which is about 20 feet in thickness. Near Mill Grove in the southeastern portion of the county, the drift, according to records of gas wells is approximately 150 feet in thickness. At Hartford City, the drift ranges from 75 to 150 feet or more. Leverett(95) reports a well record which shows a total thickness of 177 feet of drift. This well was located one mile

95) Leverett, Frank, Wells of Northern Indiana, U.S. Geol. Survey, Water-Supply Paper No. 21, 1899, pp. 77-8.

northwest of Hartford City, in Section 10. The upper 100 feet of this well consisted of till, and the remainder was largely sand. The glacial drift is composed of a compact till, with associated beds of sand and gravel, from which the best wells are obtained. The boulder clay does not supply water in sufficient quantities to wells to permit more than very restricted withdrawals.

While it is necessary in many instances in the case of private supplies to resort to the boulder clay wells, the sands and gravels usually occur in most areas and can be tapped.

The bedrock formations underlying the county are Silurian in age. These strata dip to the nowthward or northeastward. The varying thicknesses of the glacial drift indicate the unevenness of the Silurian bedrock formations. Pre-glacial erosion plus glacial erosion are responsible for this irregular surface. Some 1500 wells have been drilled in Blackford County in the search for oil and gas and from the available records the general configuration of the surface of the bedrock may be outlined.

Cumings and Shrock (96) have described the quarries at

(96) Cumings, E.R. and Shrock, R.R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Dept. of Conservation, State of Indiana, 1928, pp. 170-1.

Montpelier, which occur in the Liston Creek limestone and in the reef rock of the Liston Creek limestone, of Silurian age.

Generalized Geologic Section for Blackford County

Quaternary:

Recent,-- sands, gravels, chiefly alluvial deposits 0- 2

Pleistocene, - - glacial deposits 15-20

Silurian:

Niagaran, -- (Only few feet of Liston Creek limestone member exposed in quarries).....

Ordovician: (Not exposed in outcrops)

Cincinnatian, - - .....

Mohawkian, - -

Trenton, - - Chiefly limestone and dolomite, penetrated in wells drilled for oil and gas.

The glacial drift and the upper bedrock formations are the dependent aquifers for Blackford County.

Typical wells of Blackford County

cation ction wnship nge	Depth	Quality	Formation	Construction
24-11	67'	Hard	Limestone	Drilled
24-11	River	Soft	----	---
24-11	30	"	Gravel	Drilled
24-11	80	Medium	Limestone	"
24-10	89	Hard	Gravel	"
24-10	83	"	Limestone	"
-24-10	200	"	"	"
-24-10	180	"	"	"
-24-10	20	Soft	Gravel	Dug
-23-10	225	Hard	Limestone	Drilled
-23-10	153	"	"	"
-23-10	200	"	"	"
-23-10	85	"	Sand	"
-23-11	80	"	Gravel	"
-23-11	92	"	Limestone	"
-23-11	190	"	"	"
-23-11	81	Medium	Gravel	"
-23-11	169	Hard	Limestone	"
-24-10	100	"	Gravel	"

The above chart shows that the shallow gravel wells bear ft water, while the deeper limestone wells bear hard waters. A mmary of the above 19 wells shows 11 producing from limestone, ven from gravel and sand of the glacial drift and one from the ver. The alluvial deposits along the Salamonie and along Lick eek are locally inportant as sources of ground water.

Water Supplies of Towns in Blackford County.

Hartford City. -- (population 6,613) Haetford City obtains s water supply from two wells drilled into the underlying lime- ones. The limestone was found at a depth of 55 feet and the lls are 200 feet in depth. The static head is reported at 25 et below curb level. The bedrock formation penetrated is the ston Creek limestone.

GROUND WATER

The glacial deposits of Blackford County are the most important sources of ground water. The Niagaran limestone formations just below the drift are second in importance. It has been pointed out that the depth of wells into the drift varies from place to place. The contact of the drift and the bedrock is an excellent water horizon. Wells drilled into the bedrock at depths varying from 900 to 1000 feet penetrate the oil horizon known as the Trenton dolomite. Deeper drilling results in salt water wells.

The Liston Creek limestone which has been quarried at Montpelier is the surface bedrock in that area. Good wells occur in the joint planes and crevices of the limestone formation. On unweathered surfaces it is fairly massive and toward the base becomes argillaceous.

Little is known about the Mississinewa shale which underlies the Liston Creek limestone in this area. The Mississinewa is known to be as much as 75 feet in thickness at Wabash, Indiana, however, due to lack of detailed well sections and cuttings, the exact thickness of the Silurian formations is not known. The Mississinewa has been described as a calcareous shale or argillaceous limestone with true joint planes being rare and bedding planes infrequent. On an unweathered outcrop it would not be a conductor of ground water, so is to be omitted in any consideration of water supplies.

BOONE COUNTY

GENERAL FEATURES

Area 427 square miles Population 22,290 (Census of 1930)

Boone County is located just west of the center of the State. It is bounded on the north by Clinton County, on the east by Hamilton County, on the south by Marion and Hendricks counties, and on the west by Montgomery County. Lebanon is the county-seat.

An examination of Plate II of this report shows the county to be a portion of the Tipton Till Plain. In general the surface consists of many broad, low ridges, or divides with the local relief usually less than 50 feet, except near the stream courses. The southeastern portion of the county, in the vicinity of Zionsville and westward for five or six miles is quite rolling, with ridges extending northward and southward. This is a belt of morainal topography. A similar occurrence is found in the northeastern corner of the county, also one isolated remnant is located northwest of the center of the county. The average altitude of the county is 850 feet above sea level.

Boone County lies partly in the Wabash River drainage basin and partly in the White River basin. Sugar Creek, a direct tributary of the Wabash, crosses the northwestern portion of the county, and through its branches carries the surface waters from the northern, central, and western parts of the county. Raccoon Creek rises in the southwestern part of the county and drains a small area in that section to the Wabash. A few tributaries of Eel River rise in the southern part of the county. The eastern and southeastern parts of the county are drained by branches of the West Fork of White River. Eagle Creek flows along the eastern edge of the county.

GEOLOGY

The surface deposits of Boone County consist of sand, gravel, clays, and boulders composing the glacial drift, and alluvial deposits along the major streams. The drift in the eastern portion of the county attains a thickness of 250 to 300 feet. All of Boone County has a heavy mantle of glacial drift.

No exposures of bedrock occur in place in the county. Well records show the eastern two-thirds of the county to be underlain by strata of Devonian age. The western one-third is underlain by Mississippi (Borden) rocks. The strata dip normally to the southwestward as determined from elevations and depths of various horizons penetrated in deep wells. Little is known about the actual subsurface relationships in this county.

Generalized Geologic Section for Boone County

Quaternary:	
Recent, -- chiefly alluvial deposits	0- 50'
Pleistocene, -- glacial deposits	25-300'
Mississippian: (Not exposed at surface)	0-100'
Devonian: (Not exposed at surface)	
New Albany, -- shales	0-125'
Middle Devonian, -- limestones	40- 75'
Silurian: (Insufficient records to give thicknesses)	
Ordovician: (Insufficient records to give thicknesses)	
Trenton, -- (A well drilled at Thorntown reported a depth of 1203' to the top of the Trenton?)	

GROUND WATER

The glacial drift is the source of practically all of the water used in Boone County. The drift is unusually thick over a large portion of the county. In addition to the fact that the drift is such an excellent aquifer, the underlying bedrock formations are deficient in this respect. The Devonian strata which underlie a portion of the county consist of the New Albany impervious shales. The Mississippian strata believed to underlie the western one-third of the county consist of the Borden group which also are impervious. Wells drilled into the still deeper Devonian limestones and Silurian limestones should be expected to produce potable waters in these strata. Deeper wells from the limestones have been utilized in Indianapolis, which is almost in the same stratigraphic position as Zionsville. Lebanon is located farther down the dip and wells would of necessity go to greater depths to obtain water from the same stratigraphic horizons. This is based on the assumption of normal stratigraphic conditions, prevailing in Boone County. A well drilled at Lebanon is reported to have penetrated 210 feet of drift, and 204 feet of impervious shales. This would give a total of 414 feet of formations before the water-bearing Devonian limestones would be penetrated. No records were made of the potential water-bearing capacities of the various strata penetrated in drilling.

Wells drilled in the western portion of Boone County usually penetrate bedrock at shallower depths than those in the eastern part of the county. This is due perhaps to the more resistant character of the Borden formations to glacial erosion. The Knobstone escarpment probably extended northward and were the glacial drift removed would be a conspicuous topographic feature even today.

The contact of the bedrock formations and the drift has been an excellent ground water horizon. Frequently the upper few feet of the bedrock contain ground waters. The statement has been made that the Borden group and the New Albany shale are impervious. This is a relative condition and seep wells

should be obtained in these formations, capable of no great supplies.

In the morainal areas of Boone County satisfactory wells can usually be obtained at moderate depths. In the till portions of the county, wells find water in the clayey till or in gravels and sands associated with the till. Porous gravel beds furnish the best supplies.

The alluvial deposits are limited to the valleys of Sugar and Eagle creeks and their total area is small. They are of very limited consequence as the source of ground water.

Typical Wells of Boone County

Location	Depth	Quality	Formation	Construction
10-17-2	40- 70	Hard	Gravel-ls	Drilled
7-18-1	1-125	Med. Hard	"	"
14-18-1	40-110	" "	"	"
35-20-2	20-90	" "	Gravel	"
18-18-2	12-110	" "	"	"
6-18-2	50-110	" "	"	"
24-19-2	20-100	" "	"	"
31-19-2	15-150	" "	"	"
20-19-1	10- 95	" "	"	Dug, Driven, Drilled
4-17-1	20-150	" "	"	" "
1-19-1	20-150	" "	"	" "
24-21-1	40-150	" "	"	" "
34-19-2	15-175	" "	"	" "
8-17-2	10-116	" "	"	" "
11-17-1	10-150	" "	"	" "

Water Supplies of Towns in Boone Bounty

Lebanon. -- (population 6,445) The municipal water supply of Lebanon is obtained from six wells. The wells range in depth from 54 to 235 feet and produce from gravels of the glacial drift. The water is reported of excellent quantity and quality.

Thorntown. -- (population 1,325) The town of Thorntown has three flowing wells which produce an unlimited quantity of water, estimated as high as one and one-quarter million gallons per day. The source of the water is gravels.

Zionsville. -- (population 1,131) The town of Zionsville obtains a public supply of water from one well. The source is coarse gravel. Water stands at 15 feet below the curb. The water is slightly mineralized. Bedrock is reported at 113 feet at Zionsville.

The following table gives information secured from other towns.

Town	Depth of wells	Formation
Jamestown	70	Limestone at 40 feet
Max	10-125	Gravel and limestone
Advance	40-110	" " "
Whitestown	110	Gravel
Bigsprings	20-100	"
Dover	8-120	Gravel and limestone
Gadsden	15-150	Gravel
Hazelrigg	10- 96	Gravel
New Brunswick	20-150	"
Pike	20-150	"
Reese	40-150	"
Rosston	15-175	"
Royalton	10-116	"
Whitelick	10-150	"

CHEMICAL ANALYSIS OF BOONE COUNTY WATERS (97)

Location	Geological Occurrence	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total solids
Advance	Limestone	--	.01	--	61	25	--	0.0	366	0.0	16.	0.20	.001	2	412
Lebanon	Gravel	24	2.3	--	78	37	99	24	564	1.6	4.2	.05	--	--	622
Lebanon	Gravel	24	.4	--	53	30	31	14	301	3.6	2.5	4.0	--	--	352
Thorntown	Gravel	22	1.0	--	67	28	50	7.2	378	9.5	12.	.0	--	--	390
Whitestown	Gravel	--	1.2	--	64	27	--	.0	451	.0	12.	.05	.001	4	512
Zionsville	Gravel	--	.01	--	114	35	14	.0	345	120	112	4.	.001	4	754
Zionsville	Gravel	10	.4	.4	96	22	--	163	---	57	22	---	--	--	432
Zionsville	Till	--	.4	49	28	--	--	.0	388	.0	32	.05	2.	9	454

(97) From U. S. G. S. Water-Supply Paper 254.

BROWN COUNTY

GENERAL FEATURES

Area 324 aquare miles Population 5,168 (Census of 1930)

Brown County is located in south central Indiana, 40 miles south of Indianapolis. Nashville is the county-seat. The county has long been recognized as having rugged topography and pituresque scenery. High and long ridges, associated with deep and mature valleys make up the topographic expression of the county. The lowest elevation in the county is 515 feet above sea level. The highest is 1050 above sea level, which is the summit of Weed Patch Hill. A large part of Brown County is covered with woodland. Many of the valleys have been silted up and subsequently cleared for cultivation.

The northwestern part of Brown County is drained by Bean Blossom Creek which is a tributary of the West Fork of White River. The remainder of the county is drained by Salt Creek and tributaries which flow into the East Fork of White River. The two main branches of Salt Creek are separated by the high ridge of which Weed Patch Hill is a part. Most of the smaller streams are intermittent for at least a portion of the year.

GEOLOGY

The eastern and northern portions of Brown County were glaciated, though the effects of glaciation ar not so pronounced as are those on Bartholomew and Johnson counties which lie to the east and north. The mantle of drift is thin and near the borders is rather inconspicuous. Valley trains along Bean Blossom and Salt Creek bear outwash materials from the ice front.

The study of the surface geology of Brown County is the key to the physiographic expression. The entire county is underlain by Mississippian (Borden) strata. Due to the mature dissection by streams, outcrops are numerous. For many years the Borden group of rocks was know as the Knobstone, due to the typical knob-like topography to which it gave rise. The soft sandstones with alternating shales and lenses of limestone were easily eroded leaving ridges as remnants of the old plateau. The slopes are usually steep but not precipitous.

Generalized Geologic Section for Brown County:

Quaternary:

Recent, -- chiefly alluvial materials	0-25'
Pleistocene, -- glacial drift, valley trains .	0-50'

Mississippian:

Borden group, -- siltstones, shales, clays . . .	10-765'
Rockford, -- (Not exposed) . . . Always thin. .	6"-10'

Devonian:

New Albany, -- (Not exposed) . . . . . .50-125'?
Middle Devonian, -- limestones (Not exposed) . .40-60'

Silurian: (No records)

Ordovician: (No records)

GROUND WATER

The chief sources of water supplie in Brown County are the many shallow wells and springs. In the glaciated portions, water is obtained from the drift. In the more hilly sections, the houses are usually located in the valleys where water is obtained from natural springs or shallow wells in alluvium. Wells drilled into the bedrock frequently get inadequate supplies even for household use. The bedrock is relatively impervious. The Broden strata are composed of silstones, clays and shales, which contain some water in the interstices but wate is not given up readily from these formations. Some wells obtai potable waters from the Borden, however, many wells drilled into the Borden obtain salt water. Salt Creek heads in Brown County and is so named fron the fact that at times the water was salty.

In the early history of the county, several brine wells were utilized to supply brines in salt making. In the 6th Annua Report of the Indiana Geological Survey is a report on the geology of Brown County. (98) Collet has described the making of salt and directs attention to the occurrence of many "Licks" in the western part of the county which were known to the Indians.

(98) Collet, John, Geology of Brown County, 6th Annual Report, Indiana Geological Survey, 1874.

The intermittent character of many of the streams indicates the scarcity of ground water. During wet weather the streams run continuously but in dry weather the ground water supplies are inadequate to supply the streams with water.

Fresh waters have been reported from wells drilled into the Devonian and Silurian limestone formations, however, in plac the Borden strata are as much as 750 feet in thickness, with abu 125 feet of Devonian shale just below, which makes these horizos too deep for private wells. One deeper well reported salt wate from the Ordovician formations, believed to be the Trenton.

The Borden strata have been found to be excellent horizons to serve as bases for reservoirs. They are relatively impervios and retain impounded waters.

Water Supplies of Towns in Brown County

Nashville. -- (Population 369) Nashville residents procure water from wells. A well in the Court House yard reached the Rockford limestone at a depth of 262 feet and obtained a supply of mineral water. The Rockford limestone lies at the base of the Borden series. There is no public water supply.

C A R R O L L C O U N T Y

GENERAL FEATURES

Area 377 square miles Population 15,049 (Census of 1930)

Carroll County is situated in north-central Indiana, the fifth county from the Michigan-Indiana State line, and the third from the Illinois-Indiana State line. The maximum altitude in Carroll County is 700 feet above sea level, and the minimum is 520 feet above sea level, thus giving a total maximum relief of 270 feet. The maximum local relief is 100 feet. For the most part the county is considered as rolling. There are no high or abrupt ridges. The valley of the Wabash River is the most conspicuous topographic feature of the county, it being a mile or more in width and about 125 feet below the general level. The tributary streams do not show this entrenching effect so much.

The northwestern corner of Carroll County is drained by the Tippecanoe River and a few of its minor branches. The Wabash River crosses the northwestern portion of the county, and together with its tributaries drains the remainder of the county. Deer Creek, a tributary of the Wabash, drains the central and eastern parts of the county. Wildcat Creek crosses the southern part of the county.

GEOLOGY

The unconsolidated deposits of Carroll County consist of alluvium found in the valleys of Wabash, Tippecanoe River, Wild Cat and Deer Creeks and along many of the smaller streams. Some of the alluvium occurs as flood-plain flats and other terrace alluvium is higher along the valleys and indicates its formation during the earlier history of the parent stream. The valley flat deposits are usually full of water and wells can be obtained at little expense. The terrace alluvium is easily drained, therefore, is not so important as a source of ground water.

The glacial deposits of this county consist of moraines and till. The moraines are not prominent, but are found along the south border of the county, extending eastward from the center of the southern boundary. The northwestern quarter of Carroll County has some scattered remnants of moraines. Usually water is easily obtained from the morainal deposits. The till is thickest on the divides. Many of the streams have cut through the glacial till into the bedrock. Where porous sands and gravels occur associated with the till, good wells are obtained, however, many of the wells in clayey till are small and supply only limited amounts of water.

The bedrock formations which underlie the drift in Carroll County are Silurian and Devonian in age. Due to the mantle of drift the stratigraphic relationships in this county are only known in part. Some limestone quarried at Delphi is similar to the Liston Creek limestone of Niagaran age. It is likely that a large portion of this county is underlain by the Huntington limestone.

The northeastern corner of the county is underlain by the Kenneth limestone of Devonian age. A portion of the Kenneth is exposed at an outcrop on Deer Creek, near the Cass County line, northwest of Young America. A brown limestone of Hamilton age, also the underlying Jeffersonville limestone are found in the county. Overlying these Devonian limestones is found the New Albany shale. Outcrops of the New Albany shale have been reported from Rock Creek and from near Delphi. The Silurian strata of Carroll County consist of Kokomo limestone and Huntington dolomite. The belt of Kokomo limestone outcrops just southwest of the belt of Kenneth (Devonian) in the northeastern part of the county. The Huntington underlies the remainder of the county to the southwestward, but is overlain by Devonian strata of Jeffersonville, Hamilton and New Albany age.

Cumings and Shrock (99) have described the occurrence

(99) Cumings, E. R., and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Department of Conservation, State of Indiana, 1928, pp.110-111, et al pages.

of Huntington dolomite in a large reef northwest of Delphi, The Niagaran (Silurian) strata are unconformably overlain by a brown, thin-bedded limestone of Devonian age, which is the Hamilton rock.

Generalized Geological Section for Carroll County

Quaterrary:

Recent, -- chiefly alluvial deposits	0-50'
Pleistocene, -- glacial deposits	0-200'
Devonian;	
New Albany, -- shale	0-100'?
Hamilton, -- limestones	0-20'
Onondaga, -- Jeffersonville limestone	Not determined
Kenneth, -- limestone. (Not all exposed)	Few feet
Silurian;	
Kokomo, -- limestone	40' ?
Huntington, -- dolomite	100'
Liston Creek, -- limestone (Not exposed)	Undetermin
Mississinewa shale (Not exposed)	"
Ordovician; (Not exposed).	

GROUND WATER

Ground water is abundant in Carroll County. The county presents a large variety of surficial deposits, including the alluvium of the valley, the morainal deposits, ground moraine, and bedrock. Most of the water of Carroll County is derived from glacial drift. Inquiry was made during this study of the source of supply of 90 wells. Sixty-five produced from gravels, 16 produced from limestone and 9 produced from gravel and limestone. The drift deposits are the chief source of supply. The

till varies in thickness from a very few feet to as much as 150 feet.

Carroll County has had many natural springs. Many of the springs occur at the bases of bluffs. Some flow from the drift and others from the contact of the bedrock and the drift. The old terrace deposits along the Wabash Valley also furnish proper conditions for springs, Delphi for years has obtained a water supply from springs which issue from a gravel terrace.

The fracture joints, solution passages and bedding planes of the limestones and dolomites which form the rock surface below the drift are sources of water. Where the over-burden is thick drift, wells whose supplies are unquestionable are usually obtained. Where the rock outcrops near the surface and consist chiefly of limestones, there is some possibility of surface pollution. Some few wells in the county report the occurrence of water in joint planes of the shales, however, usually the shale wells are unsatisfactory.

Water Supplies of Towns in Carroll County

Delphi.-- (population 1,929) The town of Delphi has for years obtained a supply of water from natural springs. The springs issue from the base of a gravel terrace. Many such springs occur along the valley of the Wabash. Delphi owns the water works plant.

Flora. -- (population 1,449) The town of Flora obtains a water supply from two wells. The water horizon is about 185 feet from the surface. Bedrock was penetrated at 100 feet, and reported to be limestone. The town owns the water plant.

Camden.-- (population 538) The town of Camden receives a public water supply from one well, depth unknown, but producing from limestone which was penetrated at 80 feet.

Yeoman. -- (population 160) The town of Yeoman has no public water supply.

Typical Wells of Carroll County

Location Section Township Range	Depth	Quality	Formation	Construction
24-25-3	25'	Hard	Gravel	Driven
7-24-2	20-30	"	"	"
1-24-1	40	Soft	"	Drilled
12-24-1	100	"	"	"
1-25-1	280	Hard	Limestone	"
2-23-1	250	"	"	"
7-26-2	109	"	Gravel	"
6-25-1	63	"	"	"
11-25-2	15-65	"	"	"
1-25-1	60	"	"	"
4-25-1	30-100	"	"	"
1-25-1	63	"	Limestone	"
33-24-1	20	Soft	Gravel	"
35-24-1	162	Hard	Limestone	"
33-24-1	20	Soft	Gravel	Driven
36-24-1	25-30	"	"	Dug
36-24-1	100	"	"	Drilled
31-24-2	97	"	"	"
30-24-2	27	"	"	Driven
27-24-2	200	Hard	Limestone	Drilled
27-24-2	120	"	Gravel	"
36-24-2	180	"	"	"

(Parts per Million) MINERAL ANALYSES OF WATERS IN CARROLL COUNTY (100)

Location	Geol. cond.	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	Color	Total solids
Burrows	Gravel		.08		117	44		0.0	295	130	14	.10	000	4	562
Camden	Limestone		1.00		84	30		.0	306	25	2	.70	000	13	374
Camden	Drift		.40		127	37		.0	300	64	36	7.	000	9	632
Deer Creek	Drift		.00		136	44		.0	347	60	71	2.	000	23	706
Deer Creek	Limestone		1.00		84	34		.0	303	1.2	22	.40	.001	19	414
Delphi	Springs	21	.07		81	24	4.4	.0	350	32	1.4	16.			382
Delphi	Springs	25	.06		46	22	2.5	8.4	189	11	1.	30.			243
1½ mi. SW. of Delphi	Springs		.10		101	31		.0	299	26	3	2.	.001	9	420
N. Delphi	Limestone		1.60		72	37		.0	224	34	8	3.	.02	4	266
S. Delphi	Gravel		.05		106	33		.0	282	58	32	4.	.002	9	534
Flora	Limestone		.30		66	33		14.0	232	29	82	.10	.001	23	646
Flora	Gravel		.20		111	30		.0	316	35	8	.05	.000	13	546
Pittsburg	Spring		.80		122	36		31.0	207	65	18	12.	.001	9	496
Radnor	Gravel		.60		116	33		.0	302	18	2	.10	.001	4	384
Rockfield	Gravel		.01		194	71		.0	274	396	41	.70	.001	4	1048
Carrol	Gravel		.00		89	38		.0	252	80	74	3.00	.000	23	770
Carrol	Limestone		.20		36	33		.0	199	9.5	2	.10	.000	9	348

(100) From U. S. G. S. Water Supply Paper 254.

CASS COUNTY

GENERAL FEATURES

Area 416 square miles Population 34,518 (Census of 1930)

Cass County is located in north-central Indiana, the fourth county south of the Michigan-Indiana State line and the fourth east of the Illinois-Indiana State line. Logansport is the county seat. The county contains parts of two important stream valleys, therefore, exhibits considerable diversity of relief. The Wabash River crosses the county nearly centrally from east to west. North of the river the topography is morainic with a considerable amount of plain in the northwestern corner of the county. This latter area is drained by tributaries of the Tippecanoe River. South of the Wabash River the county is fairly smooth. Eel River drains the northeastern part of the county and enters the Wabash at Logansport. Deer Creek crosses the southern part of the county. The maximum altitude in Cass County is 826 feet above sea level and the minimum is 550 feet above sea level, thus giving a total maximum relief of 275 feet. The maximum local relief is 120 feet.

The Wabash and the Eel are the chief streams of the county. Their valleys are troughs cut below the glacial mantle, in many cases to bedrock. Where the bedrock is near the surface, narrows result but in the drift areas the valleys broaden and valley flats are formed.

GEOLOGY

The unconsolidated deposits of Cass County consist of glacial drift and alluvium. The alluvial deposits are confined to the bottom and bench areas that border the rivers. Wabash and Eel River valleys contain alluvium. Water is generally abundant in the valley flats. The terraces supply conditions for natural springs.

Morainal drift occupies a large area in Cass County, especially southwestward from the northeastern corner of the county. North of Eel River the morainal drift is very thick. Underlying the moraines occurs the usual till. Till has been reported at the surface in only two localities in the county.

In the vicinity of the Wabash River the glacial drift is thin, but in the upland areas adjacent to the river the drift reaches a thickness of 75 to 100 feet. At Walton, in the southeastern part of the county, the drift is about 80 feet and consists mainly of till. At Royal Center, in the northwestern part of the county bedrock occurs at 110 feet. Well

records indicate that the bedrock surface is uneven, which in part explains varying thicknesses of the drift.

Cass County is located partly in the synclinal area between the ends of the two geanticlines. The Kankakee Arch is to the northwest and the northwestern arm of the Cincinnati Arch to the southeast. Structurally the "sag" is a syncline. Stratigraphically it contains rocks of Devonian age, which apparently are surrounded by older Silurian rocks. This is the typical synclinal condition. Kenneth limestones of Devonian age are in the large central portion of the county, with Kokomo and Huntington strata of Silurian age on either side.

General Geologic Section for Cass County

Quaternary:	
Recent, -- sands, gravels, chiefly alluvium. .	0-50'
Pleistocene, -- glacial deposits	0-150'
Devonian:	
Kenneth limestone	0-40'
Silurian:	
Kokomo limestone	0-50'
Huntington limestone and dolomite	0-90'
Liston Creek limestone (Not exposed)	
Mississinewa shale (Not exposed)	
Ordovician: (Not exposed)	

GROUND WATER

The glacial drift is the chief source of water in Cass County. Many wells are drilled through the drift and penetrate the underlying limestone, however, the water comes from the drift. Water is generally abundant, of good quality, and easily obtained in the valley flats along the streams. Morainal drift furnishes good supplies and the till is water-bearing also, but the latter yields water sparingly. Wells of large diameter drilled into till will supply sufficient quantities of water for ordinary farm or household needs.

The bedrock limestones of Devonian and Silurian age contain water in joint crevices and along bedding planes. The upper surfaces of these formations are porous. The contact of the bedrock and drift is a source of much water in this county. Bedrock appears at the surface in the valleys of the Wabash and Eel rivers. Wells drilled a few feet into the bedrock usually obtain an abundance of potable water.

Artesian conditions exist in the vicinity of Logansport. All the deep wells in the limestone encounter water under artesian pressure. A few wells flow and in many wells the water level is near the surface.

Typical Wells of Cass County

Location	Depth	Quality	Quantity	Formation	Construction
27N-R1E Sec. 25	40-280	Hard	Abundant	Gravel & limestone	Driven & drilled
28N-R1W Sec. 23	80-180	"	"	Gravel & limestone	Driven & drilled
25N-R3E Sec. 28	15-100	"	"	Gravel & limestone	Driven & drilled
25N-R3E Sec. 33	15- 80	"	"	Gravel & limestone	Driven & drilled
27N-R2E Sec. 14	15- 60	"	"	Gravel & limestone	Driven & drilled
26N-R2E Sec. 10	15-120	"	"	Gravel & limestone	Driven & drilled
26N-R1E ec. 8	20- 80	"	"	Gravel	Driven & drilled
25N-R2E ec. 4	20-100	"	"	Gravel & limestone	Driven & drilled
27N-R1W Sec. 34	10- 50	"	"	Gravel & limestone	Driven & drilled
27N-R3E Sec. 3	20- 45	"	"	Gravel	Driven & drilled
27N-R1W Sec. 28	20- 90	"	"	Sand	Driven & drilled
25N-R3E Sec. 17	15-115	"	"	Gravel & limestone	Driven & drilled
26N-R1E Sec. 15	20-110	"	"	Gravel	Driven & drilled
28N-R2E Sec. 16	60- 90	"	"	Gravel	Driven & drilled

Location	Depth	Quality	Quantity	Formation	Construction
T27N-R3E					
Sec. 21	10- 70'	Hard	Abundant	Gravel & limestone	Driven & drilled
T26N-R3E					
Sec. 16	10-112	"	"	Gravel & limestone	Driven & drilled
T28N-R3E					
Sec. 17	12-120	"	"	Gravel	Driven & drilled
T25N-R2E					
Sec. 31	15- 80	"	"	Gravel & limestone	Driven & drilled
T28N-R3E					
Sec. 2	24	"	Good	Gravel	Dug
Sec.17	107-110	"	"	"	drilled
T28N-R2E					
Sec. 13	60	"	"	"	"
T28N-R1E					
Sec. 13	50-100	"	"	"	"
Sec. 14	25	"	"	"	"
Sec. 15	40- 50	"	"	"	"
T28N-R1E					
Sec. 16	40	"	"	"	driven
T28N-R1W					
Sec. 20	30- 35	"	"	"	"
Sec. 23	375	"	"	Limestone	"
Sec. 24	25- 40	"	"	Gravel	"
T27N-R2E					
Sec. 24	15	Soft	Fair	"	Spring waters
Sec. 21	20	"	"	"	
Sec. 21	90	"	Good	"	
T27N-R1E					
Sec. 23	80	"	"	"	In shale 40'
Sec. 28	29	"	"	"	Limestone 125-150'
Sec. 28	165	Hard	"	Limestone	Drilled
T27N-R1W					
Sec. 28	65- 70	"	"	"	Lake Cicott
T25N-R1E					
Sec. 1	68	"	"	"	Drilled
T25N-R2E					
Sec. 6	60	"	"	"	"
T24N-R2W					
Sec. 4	30	Soft	"	Gravel	
Sec. 10	27- 35	"	"	"	Open
Sec. 11	60	"	"	"	Drilled
T25N-R1W					
Sec. 31	60	"	"	"	"
Sec. 32	35	"	"	"	"

Location	Depth	Quality	Quantity	Formation	Construction
Twelve Mile	12-120			Gravel	Rock at 280'
Onward	10- 20			"	
	80-112			Limestone	
New Waverly	10- 20			Gravel	
	60- 70			Limestone	
Metea	60- 90			Gravel	
Lucerne	20-110			"	
Lincoln	15- 20			"	
	115			Limestone	
Lake Cicott	20- 90			Sand	
Hoover	20- 45			Gravel	
Georgetown	10- 47			Gravel & limestone	
Deacon	18- 20			Gravel	
	100			Limestone	
Glyners	20- 80			Gravel	
Anoka	15			"	
	120			Limestone	
Adamsboro	15			Gravel	
	30 or more			Limestone	
Young America	15- 20	-- shallow wells		Drift	
Royal Center	280			Silurian limestone	
	40- 60			Private wells	

Water Supplies of Towns in Cass County

Logansport. -- (population 18,508) The city of Logansport obtains water from the Eel River. A complete coagulation, sedimentation, filtration, and chlorination plant is in operation.

Royal Center. -- (population 777) The town of Royal Center has a public water supply obtained from three wells producing from the limestone. Bedrock was penetrated at 105 feet and water under artesian pressure rises to within ten feet of the surface.

Galveston. -- (population 666) The town of Galveston obtains water from one well which flows. Bedrock was penetrated at 100 feet. The water comes from the limestone. The well is eight inches in diameter.

Onward. -- (population 135) The town of Onward has no public water supply.

Walton. -- (population 685) The town of Walton has no public water supply.

CHEMICAL ANALYSES OF CASS COUNTY WATERS (101)
(Parts per million)

Location	Geological condition	Silica	Iron	Aluminum	Calcium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Magnesium	Nitrate radicle	Nitrite radicle	Color	Total solids
Anoka	Limestone		2.4		94			0.0	305	12	8.0	31	.49		20	502
5 mi. W. of Galveston	Limestone		1.6		44			.00	264	0.0	4.0	28	.10	.001	2	346
Galveston	Limestone		.3		69				324	318	3	28	.1		19	390
Galveston	Limestone		.1		108				320	263	3	30	.001	.01	9	562
Lake Circott	Sand		.1		66				206	18	12	25	2.5	.001	9	340
Logansport	Limestone		.5		94				306	18	4	34	.1	.002	4	576
Logansport	Limestone	12	.02	1.8	87	304	26	Tr	416	85	514	54				1274
Logansport	Limestone	18	.08	112	147	101	11		411	166	200	46	.4			906
3½ mi. E. of Logansport	Gravel		1.4		112				348	57	8	39	2.5	.005	9	490
3 mi. E of Logansport	Spring		.2		106			" -	499	42	8	26	4	.005	9	414
Long Cliff	Limestone	39	5	4.6	95	13		341		53	31	34				
Long Cliff	Limestone		1.6		113				360	36	860	62	.1		9	1992
Lucerne	Gravel		1		113				350	24	56	35		.001	2	642
New Waverley	Gravel		1		121				285	60	26	32	10	.003	13	464
½ mi. S. of Onward	Gravel		1.2		100				346		3	32		.001	2	384
Royal Center	Limestone		.5		54				305		5	29	.2	.001	2	354
Twelve Mile	Gravel		2.4		58				216	37	7	17			9	268
Walton	Limestone		1		106				336	79	4	53		.20	12	402
Walton	Sandstone		1.6		103				31	126	7	27	.3		33	292
Your America	Limestone		3.6		34				252		14	35	.05	.001	4	408
Dunkirk	Limestone		.01		131				253	84	70	28	.6	.001	9	490

(101) Water-Supply Paper 254.

CLARK COUNTY

GENERAL FEATURES

Area 375 square miles Population 30,764 (Census of 1930)

Clark County is located in southeastern Indiana on the Ohio River. It is the fifth county down the river from the Ohio-Indiana State line. Jeffersonville is the county seat. Three physiographic units are represented in this county. The Muscatatuck Regional Slope is represented in the eastern one-third of the county, the Scottsburg Lowland in the central third, and the Norman Upland in the western one-third of the county. The first two units have been glaciated with the exception of a small area south of the entrance of Muddy Fork of Silver Creek. The western one-third of the county has not been glaciated. It is a portion of the Knobstone escarpment. This area is much dissected and exhibits great local relief. The maximum altitude in Clark County is 1,020 feet above sea level, and the minimum is 375 feet above sea level, thus giving a total maximum relief of 645 feet. The maximum local relief is 500 feet. All of the drainage of Clark County enters the Ohio River, which is the south and eastern boundaries of the county. Silver Creek and tributaries drain the western and central portions of the county. Polk Creek and its branches drain the central-eastern portion, and Camp Creek the extreme eastern portion of the county. Several small streams flow directly into the Ohio.

GEOLOGY

All of Clark County with the exception of a small area west of a line extending from the northeastern corner of Floyd County to the easternmost southeast corner of Washington County has been glaciated. The drift is not thick and in many areas mantles only the higher ridges and hills. The drift appears as discontinuous patches of unsorted material, which appear to be remnants of the terminal moraines that formely marked the southernmost extent of the Illinoian glaciation. The drift is frequently exposed in the bottoms of deep ravines or on hillsides and large isolated boulders are sometimes found over the surface.

Alluvium occurs along th major streams in their lower courses and along the Ohio River. Devonian limestones outcrop in the river bed near Jeffersonville. The river deposits at this point vary from a few feet to 35 or 40 feet in thickness.

The bedrock strata of Clark County embrace parts of four systems, Ordovician, Silurian, Devonian and Mississippian. These rocks outcrop from east to west across the county. The strata normally dip westward so that a well located in western Clark County would first penetrate the Mississippian (Borden group) rocks, then Devonian, Silurian and Ordovician at greater depths.

Generalized Geological Section for Clark County:

Quaternary:

Recent, -- alluvium	0- 50'
Pleistocene, -- glacial deposits	0- 50'

Mississippian:

Borden, --siltstones, shales,	0-570'
Rockford, -- limestone	0- 10'

Devonian:

New Albany Shale,	0-130'
Beechwood, -- limestone	0- 10'
Silver Creek, -- limestone	0- 15'
Jeffersonville, -- limestone	0- 45'

Silurian:

Louisville, -- limestone	20- 60'
Waldron	10- 15'
Laurel	60'
Osgood	20'
Brassfield	2'

Ordovician:

Richmond, (Not entirely exposed)	100'

GROUND WATER

The unconsolidated alluvial deposits along the Ohio River are important sources of water. The city of Jeffersonville obtaines water from alluvial gravels. Many private supplies are obtained from similar deposits along the Ohio.

Where the glacial drift is more than just a trace or thin mantle in thickness, ground water may be obtained. However, as the drift frequently is a remnant capping ridges and hills, seeps result and no permanent supply remains in the drift. Where the drift has filled valleys and gorges, excellent wells may be obtained.

The limestone strata of the Silurian and Devonian systems are aquifers. Joint planes and solution passages permit accumulations of water. Many natural springs exist in Clark County. Even the Devonian (New Albany) shale is known to be jointed in this area, though the shale is not considered an aquifer. The Louisville limestone member of the Silurian and the Jeffersonville limestone of the Devonian are fairly thick and afford better water supplies than do the remaining members of these two systems. As the remaining formations of the Silurian and Devonian are intermixed with shale. Ordovician strata of Clark County are limited in outcrop area and are not important as sources of water. Neither are the deeply buried Ordovician strata located down in the of importance. The Trenton formations usually contain salt wat

though, some wells drilled in this county report no water in the Trenton.

The Mississippian (Borden group) strata, forming the Knobstone escarpment of western Clark County are not important as aquifers, though they are 570 feet thick at Henryville. Stockdale (102) has described the New Providence shale member of the Borden. He writes as follows about the waters of the New Providence in Clark County.

(102) Stockdale, P. B., The Borden (Knobstone) Rocks of Southern Indiana, Publication No. 98, Department of Conservation, State of Indiana, 1931. p. 89.

"In many places, especially in Clark County, the shale contains a noticeable amount of readily soluble salts; particularly sodium chloride and magnesium sulphate. Evidence of this is seen in the numerous so-called 'licks' where cattle congregate and lick the shale exposure because of its salty taste. Such a well-known shale bank is near the center of lot 274. It has been named 'Deer Lick' because, according to claims of early settlers, deer used to frequent the exposure. Occassional wells located in the New Providence shale contain water which is so strong in dissolved minerals that it is unfit for drinking. Medicinal values have been claimed for some of the waters. Probably the best known of the mineral wells are those in the vicinity of Henryville. Analysis of the water from a 'mineral well' located in the SE $\frac{1}{4}$ section 21, T. 7 N., R 6 E., $1\frac{3}{4}$ miles southeast of Underwood, follows:

Potassium bromide	3.4	(parts in one million)
Sodium chloride	203.7	
Sodium sulphate	787.9	
Magnesium sulphate	777.5	
Magnesium bicarbonate	153.7	
Calcium bicarbonate	534.9	(parts in one million)
Calcium phosphate	65.5	
Manganese bicarbonate	10.2	
Ferrous bicarbonate	32.9	
Silica	12.6	
Total	2582.3	parts in one million"

The above analysis was furnished to Mr. Stockdale by Gregg Powell on whose farm the well is situated.

In the 26th Annual Report of the Indiana Department of Geology and Natural Resources, Blatchley described several mineral springs from Clark County, all but one of which were issuing from the New Providence shale.

Typical Wells of Clark County

Township	Section or Location	Formation	Depth	Remarks
Bethlehem	4 mi. W. of Bethlehem	Limestone	80'	--------
"	Bethlehem	Gravel	110'	--------
"	Otto	Limestone	65- 75'	Drilled
Charlestown	Speeds	Shale	-------	Pond
"	"	"	15'	300'(no g Typhoid
"	Charlestown	"	16-18- 45'	----------
"	4 mi. E. of Charlestown	Limestone	35'	Hard wate
Jeffersonville	Claysburg	Gravel	20- 40'	----------
Jeffersonville	U. S. 31 Fork E. & W.	Shale	14'-65'	65' minera
Monroe	Above Henryville	"	8-10'	Along Penn R. R.
Monroe	Around Henryville	"	12-14'	Shale at 4-6'
"	Around Henryville	Borden	60'	Salt wate
"	6 mi. W. of Marysville	------	22-32'	----------
Oregon	Marysville	Shale	20-23'	----------
Owen	6 mi. E. of Charlestown	-------	95'	----------
"	Vesta	Limestone	18-20'	----------
"	Solon	"	20'	110-140' Drilled
Union	Memphis	Shale	22-28'	----------
"	1.1 mi. S. of Memphis	"	12-15'	----------
Utica	Watson	"	12-14'	80' minera
"	Prather	"	14'	----------
Silver Creek	Sellersburg	"	12-20'	90' salt water
" "	4 mi. S. Sellersburg	------	64'	Fe. S.
Washington	New Washington	Limestone	30-85-90'	Rock at 6-8'
"	5 mi. N. W. Washington	---------	18'	Hole full

Water Supplies of Towns in Clark County

Jeffersonville. -- (population 11,946) The Interstate Public Service Company provides the city of Jeffersonville with water. The supply is obtained from 34 wells drilled into sands and gravels. Bedrock is reported at 40 to 45 feet. Water stands from 20 to 25 feet from the surface.

Charlestown. -- (population 859) Charlestown has had numerous springs and at one time many citizens depended upon the springs for water. Pleasant Run flows through the west side of Charlestown, exposing the Jeffersonville and Silver Creek limestones. Water is usually obtained from the limestone at fairly shallow depths. Cisterns are prevalent also. Due to cavernous conditions of limestone, pollution is easily possible, hence the frequent use of cisterns when the quality of the supply is in doubt. The town has no public water supply.

Clarksville. -- (population 2,243) Information available does not list Clarksville as having a public water supply. It is perhaps the largest town in Indiana without a public supply. The State Board of Health report for 1932, which lists the towns in Indiana with public water supplies does not include Clarksville. The location of the town on the flood plain area of the Ohio River would indicate that private wells could obtain an abundance of water.

Claysburg. -- (population 615) The town of Claysburg has no public water supply.

Sellersburg. -- (population 1,050) The town of Sellersburg has its own water supply. One tubular well is the source of the . No data are at hand concerning the producing horizon.

New Providence. -- (population 358) The town of New Providence has no public water supply.

C L A Y C O U N T Y

GENERAL FEATURES

Area 361 square miles Population 26,479 (Census of 1930)

Clay County is located in west-central Indiana, the second county east of the location where the Wabash becomes the State line. It is the fifth county north of the Kentucky-Indiana State line. Brazil is the county seat. With the exception of a small area in the eastern part of the county which is a part of the Crawford Upland, most of Clay County is included in the Wabash Lowland physiographic unit. The maximim altitude of the county is 740 feet above sea level, the mimimum is 500 feet above sea level, thus giving a maximum total relief of 240 feet. The maximum local relief is 169 feet. All of the county was mantled with Illinoian drift. Eel River contols the drainage of the greater part of the county. This stream enters the county in the northeastern portion and flows southwesterly to a point near the central western part of the county, and then taking a southeasterly direction leaves the county near the southeastern corner. Eel River and its tributaries drain approximately ninety per cent of the surface of the county. Eel River is a tributary of the West Fork of White River. Honey Creek, Prairie Creek and other small streams in the northwestern portion of the county flow directly into the Wabash. The extreme eastern portion of the county is hilly. It is the Crawford Upland area, underlain by the Mansfield sandstone. The remainder of the county is fairly level, underlain by Pennsylvanian shales and coal beds with softer sandstone.

GEOLOGY

The uncolsolidated deposits of Clay County consist of alluvium and glacial drift.. The alluvium occurs chiefly along the Eel River and larger tributary streams. The glacial drift is thin over most of the area, ranging in thickness from a very thin mantle to as much as 20 feet. In pre-glacial valleys, the drift is thicker. In eastern Clay County the drift is thin and where bedrock outcrops has been removed by erosion. The valley of Eel River has greater thicknesses of drift. The drift is a compact till and over wide areas in the county is mantled with a thin layer of loess-like silt.

The rocks below the surficial deposits consist of shale, sandstone, and coal of the Pennsylvanian system. The Pottsville series outcrops in the eastern half of the county. The coal beds have been mined for years. The Allegheny series underlie the western one-third of the county.

Mississippian strata are exposed in the valleys of Troys Creek, Eel River, Jorden Creek and Six Mile Creek in the extreme eastern part of the county. Downward cutting of the streams has cut through the overlying strata of Pennsylvanian age to expose the Mississippian rocks of Chester age.

Generalized Geologic Section for Clay County

Qauternary:

Recent, -- chiefly alluvium and residual deposits 0- 25

Pleistocene, -- Illinoian glacial drift 0- 75

Pennsylvanian: 0-500

Post-Allegheny, -- coals, sandstones, shales, underclays (Not present in Clay County);

Allegheny, -- coals, sandstones, shales, underclays;

Pottsville, -- coals, sandstones, shales underclays;

Mississippian:

Chester, -- limestones, shales (Only few feet exposed) . . . . . .

Meramec, - -(Not exposed in Clay County) . . . .

Ste. Genevieve

St. Louis

Salem

Osage, -- (Not exposed in Clay County) . . . .

Harrodsburg

Borden

Kinderhook, -- (Not exposed in Clay County) . .

Rockford

Devonian: (Not exposed, but well drilled at Brazil reported Devonian limestone at depth of 1205 feet) . . . . . .

Silurian: (Not exposed, but well drilled at Brazil reported Silurian (Niagaran) limestone at 1615 feet) . . . . . .

Ordovician: (Not exposed at surface, but well drilled in Posey Township, Section 34, T. 12 N., R. 7 W., reported Trenton formations from 2475-3100. Surface elevation of well 630 feet) This same well reported hole full of water from St. Peter sandstone at 3100-3126. (103) . . . . . .

(103) Logan, W. N., Subsurface Strata of Indiana, Publication No. 108, Department of Conservation, State of Indiana, 1931, p. 54.

GROUND WATER

Although the older drift overlies the county, it is so thoroughly dissected and worn away that only scattered boulders and patches of till remain on the uplands. These are of little importance as sources of ground wate supply. Shallow wells in

the alluvium along the Eel River procure excellent supplies. The drift is, in the main, a compact till, and in much of the county does not afford an adequate water supply. The loess deposits usually do not attain sufficient thickness to be of importance as a source of water. The drift is generally thin, bedrock being penetrated from 5 to 30 feet below the surface.

The ground water situation in Clay County has been summarized by Leverett (104) as follows:

(104) Leverett, Frank, Wells of Southern Indiana, U. S. Geological Survey, Water-Supply and Irrigation Paper No. 26, 1909. p. 45.

"Individual wells. -- At Perth, in the northern part of the county, wells are obtained in sandy beds between the yellow and blue till at a depth of about 15 feet. A boring for coal at this village penetrated 65 feet of drift, of which the lower 50 feet is till. A boring near this village in Section 3 penetrates . . .

Surface clay	7 feet
Sand and clay	8 "
Hard blue till	37 "
Sand and clay.	11 "
Yellow till.	4 "
Total.	67 feet

In a boring 80 rods north from the preceding the drift is 48 feet and consists of till, with the exception of seven feet of sand at 30 to 37 feet.

"At Carbon the drift is mainly till, and rock is usually struck at about 30 to 75 feet.

"At Lena wells are usually 20 or 30 feet, mainly a hard blue till, and rock is not struck. A coal boring one mile west of Lena enters rock at 60 feet.

"At Harmony the drift is about 30 feet in thickness, and wells are obtained near its base or in the upper part of the rock. At a coal shaft between Knightsville and Harmony the drift is 60 feet in thickness.

"At Knightsville the drift ranges in thickness from 12 feet up to about 50 feet. Wells are often obtained here at 12 to 20 feet in a sand below the surface clay.

"At Brazil, the county seat, wells are usually obtained at about 20 feet, though they range in depth from 15 to 50 feet. The city waterworks are supplied from eight driven wells, 20 feet in depth, the water being in a gravel beneath the surface clay. It is estimated that each well will yield 1,000 barrels per day. (The present city wells, eight in number, are estimated to yield 600,000 gallons per day). Rock is frequently struck in the vicinity of Brazil at about 70 feet, though, there are several borings which penetrated 70 to 80 feet of drift. As a rule, the drift is a compact till.

"In the central portion of the county the villages of Ashcrville, Prairie City, and Saline City, obtain water in the upper part of the rock, the drift deposits being very thin, often less than 10 feet in depth. At Cory, in the west part of the county, the drift is about 40 feet, and wells are obtained without entering the rock.

"At Bowling Green, in the e stern part of the county, wells enter a sandstone immediatley below the soil and obtain water at various depths from 20 feet or less up to 60 feet or more.

"In the southern part of the county, in the vicinity of Clay City, rock is usually entered at less than 20 feet and the majority of the wells obtain water near the surface of the rock."

The bedrock strata of Pennsylvanian age are the chief sources of water in Clay County. In most places good water can be obtained at moderate depth -- 50 feet or less. The Mansfield sandstone beds underlie the county. A well drilled at Brazil, at a depth of 184 feet penetrated a sandstone stratum 88 feet in thickness. At. 1,000 feet another sandstone stratum was penetrated . This latter sandstone contained salt water. It is believed to be of Borden age. The stratum 88 feet in thickness was probably Mansfield sandstone. This horizon is not far from the outcrop of the formation and should produce good water. In many areas the Mansfield sandstone bears salt water unfit for use.

Water Supplies of Towns in Clay County

Brazil. -- (population 8,744) The municipal water supply of Brazil is obtained from eight wells, producing from the grave below the surface clay. Bedrock is reported at 40 feet. The su ly is treated with chlorine as a purification measure.

Clay City.-- (population 859) The town of Clay City has no public water supply.

Staunton. --(population 482) The town of Staunton has no public water supply.

Center Point. -- (population 372) The town of Center Point has no public water supply.

Carbon.-- (population 476) The town of Carbon has no public water supply.

Knightsville. -- (population 704) The town of Knoghtsvil has no public water supply.

Bowling Green. -- (population 257) The town of Bowling Gr has no public water supply.

CLINTON COUNTY

GENERAL FEATURES

Area 408 square miles Population 27,329 (Census of 1930)

Clinton County is located in central Indiana, just slightly northwest of the geographic center of the State. Frankfort is the county seat.

The present surface geology of Clinton County is the record of subaerial erosion on Wisconsin drift. The greater part of the county is a level till plain, although in the eastern and northern portions of the county there are several square miles covered with morainal drift. The morainal areas show greater relief than do the till surface areas. The maximum altitude in the county is 975 feet above sea level, the minimum is 775 feet above sea level, thus giving a total maximum relief of 200 feet. The maximum local relief does not exceed 100 feet.

Clinton County has no large streams. The northern and western portions are drained by the Middle Fork and the South Fork of Wild Cat Creek which is an eastern tributary of the Wabash, entering that stream north of Lafayette in Tippecanoe County. The southern part of Clinton County is drained by the head tributaries of Sugar Creek which flows southwesterly to enter the Wabash in the northwestern portion of Parke County. The South Fork of Wild Cat Creek valley is cut into the glacial drift. North of Michigantown the valley is small but becomes deeper and wider as the stream crosses the county. Most of the valleys are not deeply entrenched below the general till plain level.

GEOLOGY

The mantle of younger glacial drift is so heavy in Clinton County that most of the water supplies come from the gravel of the drift. The drift reaches a maximum thickness of 300 feet in the southern half of the county, though perhaps only 200 feet in the northern half. Well records sho this irregularity to be due to a greater accumulation in the south half, rather than due to irregularities of the surface of the underlying strata. The heavy accumulations of morainic drift in the eastern portions of the county together with increasing thicknesses of drift in this section indicate many advances and retreats of the ice front. This permitted greater accumulations of sand and gravel within the till, which is beneficial to an increased water supply. The southwestern part of the county has bedrock at depths of 125 to 150 feet.

The alluvium deposits of this county are unimportant, owing to a lack of well-developed valleys. The Middle and South Forks of Wild Cat Creek have narrow valley flats in their lower courses with alluvial deposits which locally produce water.

The bedrock strata of Clinton County do not outcrop but from well records and stratigraphic distributions in adjacent counties the strata in this county may be mapped in a general way. Devonian strata underlie the drift in the county, with the exception of some 20 square miles in the very southwestern corner which are believed to be underlain by Mississippian (Borden group) strata. At the eastern edge of the county the uppermost rocks are the Devonian limestones. Next youngest and upper-most in the central and western portions is the New Albany shale of Devonian age.

Generalized Geologic Section for Clinton County

Quaternary:
Recent, -- alluvium . . . . . 0- 25'
Pleistocene, -- glacial drift . . . . . 125-300'
Mississippian (No outcrops)
Borden group, -- (Probably underlies small area in southwestern corner of county ?) . . 0- 50'
Devonian: (No outcrops)
New Albany shale . . . . . 0-150'
Devonian limestones (Probably underlie small area in northeastern part of county) Thickness unknown
Silurian: (Reported from well records) Thickness unknown
Ordovician: (Reported from well records) Thickness unknown

GROUND WATER

The glacial till provides most of the ground water of Clinton County. Locally alluvium along the stream valleys is important but small areas limit the use. The moraines are sources of water in the southeastern portion of the county. Elsewhere they are patchy in distribution and wells must penetrate the underlying till for adequate supplies. It is necessary in many localities to drill deep into the till in order to penetrate gravel and sand beds. Many of the gravel and sand lenses are thin and do not provide enough water for average farm or domestic use, so it is necessary to depend on till water, which is usually supplied by a dug well, with greater diameter than the ordinary drilled hole.

The bedrock strata immediately underlying the drift are not aquifers. An exception is the Devonian limestone in the northeastern corner of the county, which usually contains potable water. This formation occurs at greater depths as one goes westward across the county. It is usually too deep for

private wells owing to expense of drilling, though small public supplies could be supplied. Larger city supplies could be obtained from Devonian and Silurian limestones. The city of Indianapolis supply is in part from wells producing from these strata. Michigantown has a similar location geologically, and Frankfort is down the dip so would drill deeper to the same horizons, ignoring the differences in surface elevation. The great thicknesses of glacial drift increase the drilling cost to the deeper strata.

The Devonian shale which underlies the drift of Clinton County is not considered water-bearing. It serves as an impervious layer to stop downward movement of glacial drift waters.

Wells in Clinton County in many cases are artesian, though flowing wells are scarce. Along the valley of the Middle Fork of Wild Cat Creek, near Michigantown, flowing wells have been drilled. Their low location with respect to surrounding topography is chiefly responsible for artesian flow. Wells drilled on the upland would not flow. Capps, in Water-Supply Paper 254 of the U. S. Geological Survey, published in 1910, described several flowing well areas in Clinton County. From a questionnaire mailed to various water superintendents and towns in the county and from one trip into this county, the writer has received no information that such areas still have flowing wells. Water does rise in a great many wells under artesian pressure.

Water Supplies of Towns in Clinton County

Frankfort. -- (population 12,196) The city of Frankfort is supplied with water by the Frankfort Water Works Company, a private corporation. Seven wells furnish the city with water which comes from the gravels of the drift. Bedrock is reported at 263 feet, but none of the wells produce from the underlying shales. The water level is 45 feet below the curb. The management of the water company reports a gradual recession of the water table. Many private wells are in use in the city. The glacial till and associated gravel lens are the source of supply. The city supply has been in operation for fifty years, which gives some indication of the character of the supply.

Log of Well drilled for Gas at Frankfort (105)

Clay and Hardpan with some gravel	55'
Gravel	32'
Till	113'
Sand	8'
Till	70'
Limestone and shale (Niagaran?)	380'
Clinton (Logged as Trenton)	10'
Hudson River and Utica shale	400'
Trenton limestone	260'
Total	1328'

(105) Gorby, S. S., 16th Ann. Rept., Indiana Dept. of Geology and Natural History, 1888, p. 245

Colfax. -- (population 690) Colfax is in the southwest corner of the county. One well drilled in 1927 supplies the town with water. Bedrock is reported at 85 feet, however, the water supply is produced from gravels of the drift. Water stands at three feet below the curb. Some flowing wells are found in this general vicinity.

Kirklin. -- (population 644) Kirklin, in southeastern Clinton County reports one well drilled in 1926, producing from glacial drift. Bedrock is found at a depth of 425 feet. Wells report several gravel lenses in the drift in this area.

Michigantown. -- (population 419) The town of Michigantown has no public water supply.

Rossville. -- (population 626) The town of Rossville has no public water supply.

Typical Wells of Clinton County

Location	Depth	Quality	Quantity	Formation	Construction
Frankfort	82-280'			Drift	12 wells drilled
Colfax	15-102			"	
Kirklin	30-100			"	
Rossville	26- 60			"	
Newberry	12-100			"	
Beard	20-100			"	
Boyleston	15- 45			"	
Edna Mills	10- 18			"	

Location	Depth	Quality	Quantity	Formation	Construction
Forest	15-100'			Drift -- 225' to limestone	
Greetings-ville	20-100			"	
Hillisburg	15- 65			"	
Jefferson	20- 85			"	
Manson	30- 50			"	
Michigan-town	19-125			"	
Middlefork	20- 75			"	
Moran	15- 60			"	
Pickard	15-150			"	
Scircle-ville	30-135			"	
Sedalia	15- 80			"	
T21N-R1W Sec. 10	82-208	Hard	Abundant	Gravel.	Drilled
T20N-R2W Sec. 8	15-102	"	"	"	Driven & drilled
T20N-R1E Sec. 12	30-100	"	"	"	" "
T23N-R2W Sec. 24	25- 60	"	"	"	" "
T22N-R2W Sec. 20	12-100	"	"	"	" "
T22N-R1E Sec. 7	20-100	"	"	"	" "
T21N-R1E Sec. 2	15- 45	"	"	"	" "
T23N-R2W Sec. 20	10- 20	"	"	"	" "
T22N-R2E Sec. 6	15-100	"	"	"	" "
T23N-R1E Sec. 10	20-100	"	"	"	" "
T21N-R2E Sec. 5	15- 65	"	"	"	" "
T21N-R2W Sec. 12	20- 85	"	"	"	" "
T21N-R2W Sec. 25	30- 50	"	"	"	" "
T22N-R1E Sec. 23	15-125	"	"	"	" "
T23N-R1E Sec. 10	20- 75	"	"	"	" "
T22N-R1W Sec. 3	15- 60	"	"	"	" "
T21N-R2E Sec. 36	15-150	"	"	"	" "
Sec. 3	30-135	"	"	"	" "
T23N-R1W Sec. 22	15- 80	"	"	"	" "

MINERAL ANALYSES OF WATERS IN CLINTON COUNTY (106)

(Parts per million)

Location	Geological conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total solids
Boylestown (1 mi. S. W.)	Gravel		2.2		61	27				344	55	4	.3		33	398
Colfax	Gravel		2		111	24				358	96	9		.001		448
Frankfort	Gravel		4.8		125	41				402	158	20			33	614
Frankfort	Gravel		1.2		116	39				436	269	39	.2	.06	7	706
Hillisburg	Gravel			7.7	82	32	13		202		21	4.8				
Jefferson	Gravel		.8		79	6.5				267	85	7		.001	15	370
Kirklin	Gravel		2		71	24				302	60	4			19	419
Kirklin	Gravel		1.6		34	24			9	202	32	5				314
Middleford	Gravel		.6		64	20				320	38	12	.50		6	414
Moran	Gravel		1		103	40				403	66	11		.001	19	512
Mulberry	Gravel				125	30				347	107	67	2	.1		528
Rossville	Gravel		1		116	21				345	210	15		.001	19	536
Scircleville	Gravel		.6		34	18				286	60	6	1.5	.001	33	340

(106) From Water Supply Paper 254, p. 101

C R A W F O R D C O U N T Y

GENERAL FEATURES

Area 303 square miles Population 10,160 (Census of 1930)

Crawford County is in the central-southern part of Indiana on the Ohio River. English is the county seat. The entire county is included in the Crawford Upland physiographic unit. It is the type region. The maximum altitude in Crawford County is 905 feet above sea level, and the minimum is 355 feet above sea level, thus giving a total maximum relief of 550 feet. The maximum local relief is 360 feet. Only four other Indiana counties exhibit greater maximum relief. They are Floyd, Clark, Harrison and Dearborn. Twelve other Indiana counties have greater maximum local relief.

The eastern portion of Crawford County is drained by Blue River and a few of its western tributaries. Small branches of the Patoka River gather the surface waters of the northwestern portion of the county. The western portion is drained by the upper tributaries of Anderson River. The extreme southern portion is drained by the Ohio River and small streams which flow into the Ohio.

GEOLOGY

The unconsolidated deposits of Crawford County consist of alluvium and residual materials. The county is in the driftless area of Indiana. Alluvium is found in the lower portions of the larger streams, but owing to the ruggedness of the county with streams of high gradient, these deposits are not extensive.

The geological formations exposed at the surface in Crawford County are of Quaternary, Pennsylvanian and Mississippian age. The Quaternary deposits are the alluvial materials of Recent age and gravels on elevated benches. The Pennsylvanian strata consist of sandstones and shales of Pottsville age, which cap high hills and ridges in the western half of the county. A few of the hills are capped with Pennsylvanian outliers. Chester series formations of the Mississippian occupy a large area in this county. Their thickness is between 500 and 600 feet, with all the formations present except one or two in the upper portion. Eastern Crawford County is underlain by the Ste. Genevieve limestone. At Milltown about ten feet of the St. Louis is exposed. The St. Louis and other formations dip to the westward. The Wyandotte and Marengo caverns are developed in the Ste. Genevieve limestone.

Generalized Geologic Section for Crawford County

Quaternary:
Recent, -- chiefly alluvium . . . . . .0- 25'

Pennsylvanian:
Pottsville, -- sandstones shales, coal, clays. . . . . 0- 50'

Mississippian:
Chester, -- limestones sandstones, shales . . . 0-550'
Meramec:
Ste. Genevieve, -- limestone. . . . . .100-150'
St. Louis, -- limestone . . . . . .10' exposed
Osage and Kinderhook strata not exposed. . . .

Devonian: (Not exposed, but penetrated by oil and gas wells. Surface elevation 530, depth to top of New Albany shale 1450 feet, in well known as D. W. Jones No.1, Section 30, T. 2 S., R. 2 W.)

Silurian: (Not exposed, but reported from wells) . .

Ordovician: (Not exposed, but reported from wells) . .

Note: The records of several deep wells drilled in Crawford County are given in Publication No. 108, The Sub-Surface Strata of Indiana, by W. N. Logan, Department of Conservation, State of Indiana, published, in 1931, pp. 57-61.

GROUND WATER

Precipitation records of the U. S. Weather Bureau show that Crawford County receives more inches of rainfall than do other Indiana counties. Without doubt the rugged topography i responsible for this precipitation running away to the rivers and it is perhaps a fact that a smaller proportion of the annu rainfall actually penetrates the underground formations than i the case with some of the less rugged counties with less pre- cipitation. Nevertheless Crawford County has many natural springs. The Chester formations consisting of alternating lim stones, sandstones and interbedded shales give the proper geol gical conditions for springs. The shales are impervious and a as a down-stop to prevent the water from seeking lower levels. The water moves down the dip and issues as a spring, where the water table is intersected by the surface. Many of the spring are perennial and do not fail in the driest weather. Others show a decrease in volume in prolonged droughts. The limeston formations of the Chester, such as the Negli Crock, Siberia, Glen Dean, Golconda, Beech Creek, Reelsville and Pabli conta in solution passages and joint crevices along which water moves. Frequently an overlying sandstone formation acts as a feeder to the limestone bed. Where the limestone is underlain by an impervious shale or massive non-porous stratum, the water move horizontally, frequently resulting in springs, or discharges into streams. The Ste. Genveieve and St. Louis formations ar

noted for subterranean drainage and much surface water escapes through their underground conduits. The Chester limestones tend to develop caverns and subterranean drainage but do not compare with such features developed in the St Louis and Ste. Genevieve. The Ste. Genevieve is the cavern formation in Crawford County.

The Cypress sandstone-Beech Creek limestone horizon is noted for the occurrence of springs in Crawford County. Several of the towns in this county and many private supplies come from springs. Many dug wells, also drilled wells, are in use. Cisterns are also common.

In the 26th Annaul Report of the Indiana Department of Geology and Natural Resources, W. S. Blatchley describes some artesian wells and springs of Crawford County which are highly mineralized. They are described as saline-sulphuretted, and alkaline, saline wells and springs. The 1878 report of the Indiana Survey describes salt wells in the county, one of which yielded sufficient brine to make 20 barrels of salt per day.

Water Supplies of Towns in Crawford County

English. -- (population 704) The town of English is supplied with water from natural springs. The Beech Creek limestone is the water bearing stratum. It is overlain by the Cypress sandstone which transmits water to the joint crevices and bedding planes of the Beech Creek.

Leavenworth. -- (population 418) The town of Leavenworth is supplied with spring water. The spring issues from near the base of the Ste. Genevieve limestone. After heavy rains the spring water is cloudy to muddy which indicates some surface connections.

Marengo. -- (population 806) The town of Marengo receives a water supply from one spring. This water issues from the Ste. Genevieve limestone.

Alton. -- (population 109) The town of Alton has no public water supply.

Milltown. -- (population 795) (In Crawford County, population 605; in Harrison County, population 190.) The town of Milltown has no public water supply.

D A V I E S S C O U N T Y

GENERAL FEATURES

Area 433 square miles Population 25,832 (Census of 1930)

Daviess County is located in southwestern Indiana, the second county east of the Illinois-Indiana State line and the third north of the Kentucky-Indiana State line. Washington is the county seat. The county lies between the two forks of White River. The West Fork of White River is the western county boundary and the East Fork is the southern boundary of the county. The entire county is included in the Wabash Lowland physiographic unit. The maximum elevation of the county is 690 feet above sea level, the minimum is 400 feet above sea level, thus giving a total maximum relief of 290 feet. The maximum local relief is 175 feet. The eastern portion of the county is within the outcrop belt of the Mansfield sandstone which gives rise to a broken topography with high hills and steep slopes. In general the topography of the county is rolling with an approach to broken and hilly topography as the streams and drainage courses are neared.

In addition to the West Fork of White River which borders the county on the west, the drainage courses are Furst Creek, Indian Pond Creek, Smithers Creek, Prairie Creek and Veale Creek, all tributaries of the West Fork. East Fork of White River and its tributaries, Aikmans Creek, Camp Creek, Mud Creek, Sugar Creek and Slate Creek contribute to the drainage of the county.

GEOLOGY

The unconsolidated deposits of Daviess County consist of glacial drift, valley alluvium, and residual deposits. All of the county was mantled with Illinoian drift, though the eastern border of the county is near the margin of the drift. The drift is thin on the uplands, absent in many areas and fills many valleys to considerable depths. The two forks of White River bound the county on the west and south. Alluvial materials occur chiefly along the flood plains of these two rivers. The lower courses of the larger streams have alluvial deposits also. The residual materials are clays, sands and soils formed by weathering of the drift, and bedrock.

The bedrock strata which outcrop in Daviess County consist of Pottsville and Allegheny rocks. Pottsville rocks outcrop in the northeastern corner of the county and along the eastern border. Most of the county has exposures of Allegheny series strata. Drift, alluvium and residual materials cover the bedrock.

Generalized Geologic Section for Daviess County

Quaternary:
- Recent, -- chiefly alluvium . . . . . 0- 50'
- Pleistocene, -- glacial drift, Illinoian. . . 0- 75'

Pennsylvanian: . . . . . .200-450'
- Allegheny, -- sandstones, shales, coals
- Pottsville, -- sandstones, shales, coals

Mississippian: (No exposures mapped)
- Chester, -- (No outcrops of Chester strata have been mapped in Daviess County, but it is probable that in the northeastern corner of the county some members of the Middle Chester may be exposed along Purse Creek)

GROUND WATER

Ground water is obtained in Daviess County from wells, springs, and indirectly from streams. Streams are supplied with water by seeps from the ground water supply. The flood plains of White River are important sources of supply. the glacial drift, where of sufficient thickness, contains water, though in many areas is entirely too thin and in still other areas is drained.

Water for household and farm use may be obtained usually from dug or driven wells. These wells are shallow or of moderate depth. The water comes from Pennsylvanian formations, coal, sandstone and shaly sandstones. Private wells furnish enough water for family use but are not strong enough for public supply systems. At Washington it seemed more practical to procure water from White River than to attempt development of the underlying ground waters. Deeper wells in Daviess County penetrate the Mansfield sandstone which is an aquifer. The Mansfield is frequently shaly in composition and not water-bearing in localities. Ofttimes salt water occurs in the Mansfield. Well records from many wells drilled in the search for oil and gas in this county show the Mansfield to carry potable water. Owing to the fact that the Mansfield was laid down on an eroded surface, the thickness of the formation varies, so this is another hazard in anticipating a Mansfield sandstone water supply. Other Pennsylvanian strata also bear potable water supplies.

The Mississippian formations which underlie the county bear potable waters in many wells. Some of the Chester formations are very porous, though the well records indicate blue lick water in many Mississippian strata. Down the dip westward from the outcrop many of the Mississippian limestones become shaly and at depth are not aquifers.

Water Supplies of Towns in Daviess County

Washington. -- (population 9,070) The city of Washington obtains a water supply from the West Fork of White River. The city owns the plant. A complete coagulation, sedimentation, and chlorination plant is reported.

Cannelburg. -- (population 132) The town of Cannelburg has no public water supply.

Montgomery. -- (population 445) The town of Montgomery has no public water supply.

Elnora. -- (population 856) The town of Elnora has no public water supply.

Odon. -- (population 981) The town of Odon has no public water supply.

Alfordsville. -- (population 90) The town of Alfordsville has no public water supply.

Plainville. -- (population 603) The town of Plainville has no public water supply.

DEARBORN COUNTY

GENERAL FEATURES

Area 313 square miles Population 21,056 (Census of 1930)

Dearborn County is located in the southeastern part of the State. The Ohio River is the State boundary between Kentucky and Indiana at the southeastern margin of Dearborn County. The Ohio-Indiana State boundary is also the eastern margin of the county. This county is the type of the Dearborn Upland physiographic unit. It is rather maturely dissected, with many streams of varying size, and little level land. The streams have formed deep, narrow valleys with steep slopes and high gradients. The Ohio River has cut a gorge on the east side of the county about 400 feet deep. From Laughery to Aurora the bluffs are close to the river. Above Aurora the bluffs gradually recede, thus making extensive bottom lands between Aurora and Lawrenceburg nearly two miles in width. The maximum altitude in Dearborn County is 1010 feet above sea level, and the minimum is 425 feet above sea level, thus giving a total maximum relief of 585 feet. The maximum local relief is 400 feet.

Dearborn County is drained by the Ohio River and tributaries. Laughery Creek forms the south boundary of the county and a few of its branches drain the southwestern and southern part of the county. Laughery creek flows northeasterly to enter the Ohio. About six miles to the north is south Hogan Creek which flows parallel to Laughery Creek. Still farther north is North Hogan Creek which joins South Hogan at Aurora. Tanners Creek rises in the northwestern part of the county and flows in a southeasterly direction to the Ohio. The Whitewater River crosses the northwestern corner of the county, crosses into the State of Ohio and then discharges into the Miami River in the southwestern corner of the State of Ohio.

GEOLOGY

The unconsolidated deposits of Dearborn County consist of glacial drift, alluvial materials, and residual soils. The glacial drift of Illinoian age occurs as a thin mantle on the higher ridges. Erosion has removed much of the drift so that only patchy remnants remain. The Whitewater valley is filled with valley train materials, which contain an abundance of ground water. The other streams contain valley flats in their lower portions, however, the majority of streams have high gradients and do not deposit much load. Terraces along the Whitewater were made by deposition of gravels and sands by glacial waters. The residual materials consist of soils gathered from drift and from the bedrock.

The bedrock strata of Dearborn County are of Ordovician age. The Eden, Maysville, and Richmond groups are represented Limestone layers with associated shales make up these formatio

Generalized Geologic Section for Dearborn County

Quaternary:
Recent, -- alluvial deposits. . . . . .0- 40'
Pleistocene, -- glacial deposits. . . . . .0-140'

Ordovician:
Cincinnatian, -- limestones, shales . . . . . 500'

GROUND WATER

Glacial drift and alluvial deposits are the chief sources of ground water in Dearborn County. Where flood plains are found along streams, valley trains or other outwash materials as terraces or alluvial deposits, and glacial drift of sufficient thickness occur, ground water may be developed. Much of the drift is too thin to contain water supplies. Shallow wells drilled into limestones are frequently developed for private supplies. A few springs are found in the county. Cisterns are used where ground water cannot be developed. Where farm houses are located on uplands ground water is difficult to obtain, unless the glacial drift is fairly thick. Where supplies are developed in the lowlands and wells are drilled into alluvial deposits, the chances for securing ground water are good. The Ordovician strata consisting of limestones and shales, lying essentially flat are relatively impervious. Ground water is found in the limestones, but many of the limestone strata are hard and dense. Solution channels are not as well developed as in The Mississippian limestones, however, joint planes and bedding planes permit circulation of ground water. The mature dissection of this upland area, with deeply incised streams permits seepage from the uppermost strata. Ground water is not highly developed in this county. The deeper formations such as the St. Peter have contained water unfit for consumption, so deeper drilling cannot solve the ground water problem. Fortunately, the largercities of the county are located adjacent to the Ohio and can depend on this stream or adjacent valley flat deposits.

A well at Dillsboro reported fresh water at 79 feet and highly mineralized water at 1220 feet. This latter horizon is thought to be the St.Peter sandstone of Ordovician age.

Water Supplies of Towns in Dearborn County

Aurora. -- (population 4.386) The city of Aurora is furnished water by the Interstate Public Service Company, a private corporation. The supply is obtained from the Ohio River and treated by various methods to insure purity.

Lawrenceburg. --(population 4.072) A municipal water supply obtained from tubular wells serves the city of

Lawrenceburg. Three wells drilled into alluvial gravels procure water at depths from 60 to 70 feet. Bedrock is reported at 127 feet, but no water is obtained from the bedrock. The wells are six inches, eight inches and fourteen inches in diameter.

Greendale.-- (population 1,050) The town of Greendale is supplied water from four wells drilled into gravels. The depth is given as 116 feet. Bedrock is reported at 127 feet. The wells are privately owned. Production is estimated at 1,000,000 gallons per day.

West Harrison. -- (population 279) The town of West Harrison is supplied with water from tubular wells. The supply is privately owned.

Dillsboro. -- (population 502) The town of Dillsboro has no public water supply.

St Leon. -- (Population 276) The town of St. Leon has no public water supply.

Moores Hill. -- (population 349) The town of Moores Hill has no public water supply.

D E C A T U R C O U N T Y

GENERAL FEATURES

rea 378 square miles Population 17,308 (Census of 1930)

Decatur County is located in southeastern Indiana the econd county west of the Ohio-Indiana State line, and the third ounty north of the Kentucky-Indiana State line. Greensburg is he county seat.

A small area of the northeastern portion of this county is ncluded in the Dearborn Upland, but most of the county is in- luded in the Muscatatuck Regional Slope. The maximum elevation s 1030 feet above sea level, the minimum is 690 feet, thus iving a total maximum relief of 340 feet. The maximum local elief is 140 feet. The Illinoian glaciation completely covered he county. The Wisconsin drift mantled the county in part. he last drift margin extends from the very southwestern corner f the county to the northeastern corner, leaving about one-third f the area unglaciated by the Wisconsin. The margin of the rift is shown by terminal moraines of the Shelbyville substage.

Most of the surface drainage of Decatur County is accomplish- d by tributaries of the East Fork of White River. The north- estern part is drained by Big Flat Rock Creek, Little Flat Rock reek, and Clifty Creek. The central and southwestern portions re drained by Sand Creek and its tributaries. Muscatatuck Creek ises in the southeastern part of the county and flows southwest- ard. Salt Creek originates in the northeastern portion of the ounty and flows to the Whitewater River.

In general the topography of the county is that of narrow, evel creek valleys and high, irregularly dissected uplands, with he hills rising 30 to 75 feet above the adjacent valleys.

GEOLOGY

The unconsolidated deposits of Decatur County consist of acial drift and alluvium. The thickness of the drift is ually less than 50 feet, and at many places wells penetrate drock at 20 feet or less. A few wells have recorded as much 150 feet of drift. Ancient valleys existed before the advent the glaciers. These valleys were filled which explains the rying thickness of the drift. Also the old land surface was oven over which glaciers moved. Many of the bedrock irregu- rities date back to that pre-glacial topography.

The outer limit of the Wisconsin glacier is marked by a rminal moraine, however, the moraine is not conspicuous. The ry northwestern corner of the county is crossed by a moraine ich parallels the outer marginal moraine. Most of the drift

deposits of the county consist of till.

The bedrock formations of Decatur County are Silurian, Devonian and some inliers of Ordovician. The latter are outcropping in some stream valleys in the southeastern part of the county. They are exposed by downward cutting of streams. The Silurian strata occupy the eastern and southeastern portions of the county. The remainder of the county is underlain by Devonia formations, chiefly limestones. In the northwestern part of the county along the floors of stream valleys occur some inliers of Silurian. Deep cutting by the streams is responsible for these occurrences.

Generalized Geologic Section for Decatur County

Quaternary:	
Recent, -- chiefly alluvial deposits, residual soils.	0- 25'
Pleistocene, -- glacial drift	0-150'
Devonian:	
Middle Devonian, -- limestones	40- 50'
Silurian:	
Louisville, -- limestone.	0- 10'
Waldron, -- shale	5- 10'
Laurel, -- limestone	50- 60'
Osgood, -- limestone and shale	15- 20'
Brassfield, -- limestone.	2- 4'
Ordovician:	
Richmond, -- limestones and shales (Upper surface of Ordovician of Indiana exposed)	15- 2[illegible]

GROUND WATER

Supplies of ground water may be obtained in Decatur County from either glacial drift or bedrock formations. The drift is usually of sufficient thickness to be an aquifer and in most places sand and gravel lenses are penetrated in the drift. Man till wells do not furnish large supplies, so it is necessary to penetrate bedrock or gravel beds in deeper till.

In the vicinity of Clarksburg and Kingstone, in the northes part of the county, wells are obtained at 20 to 40 feet in beds of sand and gravel. At Mechanicsburg, which is located on the Illinoian drift, wells secure water at 15 to 20 feet without penetrating rock. At Greensburg many private wells obtain wate from the drift, near the base of the drift or even in bedrock. The latter is penetrated at approximately 50 feet. At Westport wells in some cases enter rock at about 30 feet, but many obtai water in the drift. At Sardinia wells penetrate bedrock at 25 to 35 feet. At Adams which is on the northwestern morainal bel

ells obtain water in the drift, though bedrock is reported at epths varying from 20 to 30 feet. A thick section of drift was enetrated in the northwestern corner of the county in a gas ell boring. Rock was penetrated at 150 feet. Leverett, in ater Supply Paper No. 26 gives the following log of the drift.

Till	19'
Sand	4'
Blue till	52'
Gravel and sand	15'
Yellow till	5'
Oily blue clay, with few pebbles	16'
Coarse gravel	15'
Hard blue till	20'
Total	146'

Water Supplies of Towns in Decatur County

Greensburg. -- (population 5,702) The city of Greensburg is urnished water by the Indiana Water Works Company, a private orporation. The water is obtained from 10 tubular wells which roduce from the limestones underlying glacial drift. The water evel is at 55 feet. Bedrock is penetrated at 45 feet. Two of he wells are six inches in diameter, five are eight inches, and hree are twelve inches in diameter. The water probably comes rom the Silurian limestones, which outcrop in the creek less han one mile southeast of Greensburg. The glacial drift waters ercolate downward into joint crevices and solution channels in he limestones. All of this county is underlain by limestone ormations which adjacent to the drift are excellent aquifers.

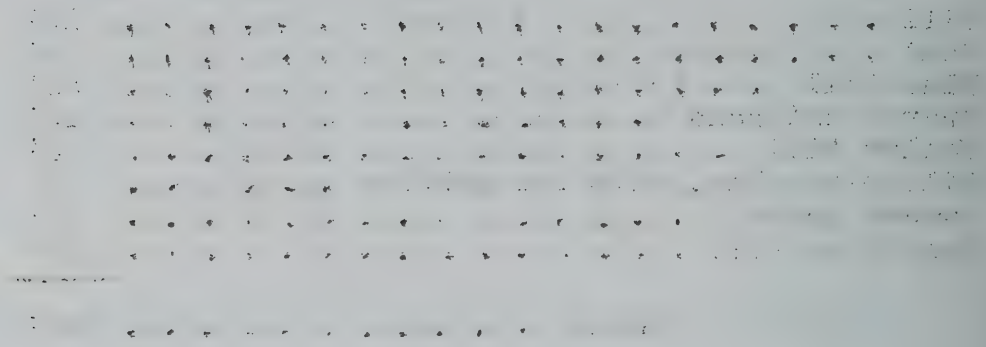
Milford. -- (population 152) No public water supply is eported for the village of Milford.

St. Paul. -- (population 678) The town of St. Paul is urnished water from private wells. There is no public supply ccording to present information.

Millhousen. -- (population 162) The village of Millhousen as no public water supply.

Newpoint. -- (population 342) The village of Newpoint has o public water supply.

Westport. -- (population 637) The town of Westport has no ublic water supply. Private wells obtain water from the drift, r from bedrock which is penetrated about 30 feet.



DEKALB COUNTY

GENERAL FEATURES

Area 370 square miles Population 24,911 (Census of 1930)

DeKalb County is located in northeastern Indiana, bordering the State of Ohio, and is the second county south of the Michigan-Indiana State line. The maximum altitude in the county is 1,025 feet above sea level and the minimum is 775 feet. This gives a maximum relief of 250 feet. The maximum local relief is 100 feet.

Dryer (106) describes the topography of the county as follows;

(106) Dryer, Charles R., Report upon the Geology of DeKalb County, 16th Anrual Report, Indiana Department of Geology and Natural History, 1888 (1889), pp. 98-104.

"The lowest point in the county, at the southeast corner, is about 775 feet above sea level; the highest, near the northwest corner, has an elevation not far from 1000 feet. Between these limits the relief of the surface consists of three parallel ridges with two intervening valleys, which cross the county in a direction nearly northeast and southwest. It is as if some gigantic plow had turned three furrows, the northwestern one being a 'back furrow' thrown up against another turned from the opposite direction. To a certain extent this comparison is a simple statement of fact, but the whole fact is not quite so simple. The Van Wert and Hicksville ridge, which marks the shore line of a body of water elsewhere described as Maumee Lake, touches the county at the southeast corner. Between that and the St. Joseph River lies the first great ridge, five miles wide and with an elevation at the summit of 76 feet above the Hichsville ridge, and of 60 feet above the river. It occupies the township of Newville and portions of Concord and Stafford. West of the St. Joseph a second great ridge, about eight miles wide, occupies the townships of Troy, Stafford, Wilmington, Jackson, one half of Union, and the great part of Concord and Franklin. It is bounded on the west by the valley of Cedar Creek, and the prolorgation of that valley from the northern part of Union to Aldrich Lake on the north line of Franklin. The crest of this ridge, within a mile or two of its western border, is about 125 feet above the St. Joseph, 60 feet above Cedar Creek, and averages 65 feet higher than the first ridge. A third ridge, still more massive and elevated, occupies the townships of Fairfield, Smithfield, and the greater part of Richland, having its watershed near the northwestern border of the county and its longest slope in Noble, Lagrange and Steuben counties. Its summit is probably nowhere less than 1,000 feet above the sea, and from 100 feet to 150 feet above Cedar Creek Valley.

"The eastern border of this ridge can be distinctly

traced along the road from Hamilton, Steuben County to Waterloo. On the road from Auburn to Corunna it is marked by a sharp rise at the southwest corner of Section 13, Richland, whence it continues as a well defined bluff to the southwest corner of Section 27, thence southward along Little Cedar Creek. Cedar Creek valley therefore increases in width from one mile at Aldrich Lake to five miles in Butler township."

With the exception of a small area in the extreme northwestern part of the county in which the drainage goes to Pigeon River, the drainage of the county is controlled by the St. Joseph River and its tributaries. Cedar Creek is responsible for the drainage of the western and large part of the central part of the county. A number of lakes are present near the head waters of the streams. Among the largest lakes are Indian and Cedar Lakes in the northwestern portion and Rondy Lake in the southern part of the county.

GEOLOGY

The unconsolidated deposits of DeKalb County consist of alluvial materials along the main streams and glacial deposits which mantle the entire county. Also some of the old lakes have been filled with muck and vegetation, which have caused the lakes to become almost extinct.

The glacial drift of DeKalb County is very thick averaging perhaps 250 to 300 feet.

Dryer gives the following section from a well drilled for gas at Butler.

Hard-pan (generally clay)	15'
Gravel and coarse sand	275'
Red quicksand	40'
Clay (glacial rite)	45'
Cobble stones and boulders	3'
Total	378'

A well drilled at Waterloo had drift 365 feet, one at Auburn 280 feet, one at Garrett 318 feet.

Leverett in Water Supply Paper No. 21 has called attention to the occurrence of a sheet of till extending over the greater part of the county. It occurs at an average depth of 50 feet. Water is seldom found in large amounts in this till sheet. Below the sheet of till the drift appears to be very largely sand and gravel and yields an unlimited amount of water. There are many narrow belts bordering the valleys in which water may be obtained in gravel or sand at comparatively slight depths.

The bedrock formations of DeKalb County are entirely concealed below the drift. From well records it has been

determined that strata of Mississippian (Borden) age underlie the drift in the northern part of the county and formations of Devonian age underlie the drift in the southern one-third of the county. The bedrock surface was eroded before the deposition of the till so it is difficult to predict the approximate thickness of the drift in any particular locality. A few preglacial stream channels are known and the drift is thicker in those areas, especially where the present drainage does not follow the preglacial drainage.

Generalized Geologic Section for DeKalb County

Quaternary:
Recent, -- alluvium, residual soils . . . . . 0-25'
Pleistocene, -- glacial deposits . . . . . .200-378'
Mississippian: (not exposed at surface)
Borden, -- (determined from well logs) . . . . . 0-300'
Rockford, -- (limestone, not recognized by drillers) . . . . . .
Devonian:
New Albany, -- shale (determined from well logs). 100-150'
(Believed to underlie drift in southern one-third of county)

GROUND WATER

Surface supplies. -- The sources of surface water supply in DeKalb County are streams, lakes, springs, and from impounded waters in artificial reservoirs. Lake supplies are limited to only a few localities. Many of the streams are intermittent and only those fed by lakes or springs have permanent supplies. Cedar Creek and the St. Joseph River contain permanent supplies.

Ground water. -- Ground water is found everywhere in the glacial drift in DeKalb County. Some of the wells flow and in many wells water stands near the surface. Water is found in wells at depths ranging from 20 to 230 feet into the drift. The average depth of wells has been determined to be about 50 feet. The occurrence of a layer of till at about a depth of 50 feet will perhaps explain this average well depth. In the clayey till water is seldom found in large amounts, so it is necessary to penetrate the sandy layers of gravel underlying the till.

The rock formations which underlie the drift in DeKalb County are not aquifers. The formations have been determined to be Devonian shales and Mississippian (Borden) siltstones and shales. Both of these series are relatively impervious and will not yield ground water. There are no available records of the quality of waters in deeper strata. The Devonian limestones and Silurian limestones should bear potable waters as the county is not far removed from the area where these water-bearing strata are in immediate contact

with the drift. Another important factor to be considered is that the strata of DeKalb County are located northeast of the Cincinnati Arch and are dipping toward the Michigan sedimentary and structural basin. This basin has been in existence for geological epochs and ground water does not circulate, but on the contrary stagnates and becomes brackish or salty. It is possible that this reaction would cause the Devonian limestone and Silurian limestone waters to be unfit for use. A test well is the only method known to ascertain the quality of the deeper waters. A few wells have been drilled for oil and gas, however, no records seem to be available concerning the quality of water in the deeper horizons. The Trenton formation, believed to have been penetrated at Garrett at 1980 feet is reported to bear salt water.

Water Supplies of Towns in DeKalb County

Auburn. -- (population 5,088) The city of Auburn has a municipal water department which obtains a supply from 10 wells drilled into the gravels of the glacial drift. The wells are 10 inch wells and are estimated to produce 1,000,000 gallons of water per day. No variation in supply has been noted with the seasons and the general character of the water is excellent.

Butler. -- (population 1,643) The city of Butler is furnished water by a privately owned group of five wells, drilled into the drift, depth unknown. Water is reported to rise within 16 feet of the curb.

Waterloo. -- (population 1,244) The town of Waterloo is supplied water from two wells, privately owned. The water level is reported at 30 feet.

St. Joe. -- (population 407) The town of St. Joe has no public water supply. Private wells obtain water from the glacial drift.

Altona. -- (population 342) The town of Altona has no public water supply. Private wells obtain water from the drift

Garrett. -- (population 4,428) The city of Garrett has its own water system. Nine wells drilled into the glacial drift furnish the water. The wells are eight and ten inch wells. Water stands within 11 feet of the surface.

Corunna. -- (population 268) The town of Corunna has no public water supply. Private wells obtaining water from the drift are in use.

Ashley. -- (population 623; 336 in DeKalb, 287 in Steuben) The town of Ashley has no public water supply. Private supplies are obtained from the drift.

Typical Wells of DeKalb County

Location	Depth	Quality	Quantity	Formation	Construction
T33N-R12E					
Sec. 4	130-230'	Hard	Good	Gravel	Drilled
Sec. 26	40'	"	"	"	"
T34N-R12E					
Sec. 4	110'	"	"	"	"
Sec. 9	30-60'	"	"	"	"
T35N-R12E					
Sec. 22	110'	"	"	"	"
T35N-R13E					
Sec. 17	80'	"	"	"	"
Sec. 21	60'	"	"	"	"
T34N-R14E					
Sec. 5	43'	"	"	"	Driven
Sec. 11	110'	"	"	"	Drilled
T35N-R14E					
Sec. 4	80-100'	"	"	"	"
Sec. 25	40'	"	"	"	"
T34N-R13E					
Sec. 34	35'	Soft	"	"	Drilled
Sec. 24	50'	"	"	"	"
Sec. 21	45'	"	"	"	"
Sec. 29	45'	"	"	"	"
T34N-R13E					
Sec. 19	60'	"	"	"	"
Sec. 24	10-15'	"	Fair	"	Driven
Sec. 25	140'	"	Good	"	Drilled
Sec. 25	44'	"	"	"	"
Sec. 19	40'	"	"	"	"
Sec. 25	24'	"	"	"	"
Sec. 19	40'	"	"	"	"
T35N-R15E					
Sec. 6	20'	"	"	"	Driven
Sec. 6	84'	"	"	"	Drilled
Sec. 6	120'	"	"	"	"
Sec. 6	90'	"	"	"	Average Depth
Sec. 6	40-50'	"			Drilled-St.Joe
	(Shallow wells have poor supply)				
T33N-R14E					
Sec. 16	33'	Soft	Good	Gravel	
Sec. 16	56'	"	"	"	Drilled
Sec. 16	74'	"	"	"	"
T33N-R12E					
Sec. 14	30'	"	"	"	"
Sec. 23	32'	"	"	"	"
Sec. 13	Flowing Wells		"	"	"
Sec. 15) 16)	50'	"	"	"	"
Sec. 27	40'	"	"	"	"
Sec. 16) 17)	50'	"	"	"	"

D E L A W A R E C O U N T Y

GENERAL FEATURES

ea 392 square miles . . Population 67,270 (Census of 1930)

Delaware County is located in east-central Indiana. It is e second county west of the Ohio-Indiana State line and the xth county south of the Michigan-Indiana State line. It is also e sixth county north of the Kentucky-Indiana State line.

The maximum altitude of the county is 1,075 feet above sea, d the minimum is 865 feet above sea level, thus giving a total ximum relief of 210 feet. The maximum local relief is approx-ately 80 feet. The entire county is included in the Tipton ll Plain area. The northeastern corner of the county is vered by a moraine. Another moraine trends eastwest across e central part of the county and the southeastern corner is cupied by a heavy morainal deposit. The western half of laware County is a gently undulating plain, also the central rtion, though the stream courses present broken areas. In the cinity of Muncie are found some sharp gravelly knolls and an ker of considerable prominence near Royerton. A number of mes or rounded hills of gravel are located in the area between ncie and Granville and Smithfield.

Two main drainage lines cross Delaware County. The East rk of White River crosses the south-central portion of the unty and the Mississinewa River crosses the northeastern portion. uthern tributaries of White River which collect the surface ters of the southern part of the county are, in order from east west: Ditty Creek, Bell Creek, Prairie Creek, and Stony Creek. rthern branches of this stream are Big Pipe, Kilbuck and Mud eeks. Pine Creek flows northward into the Mississinewa River.

GEOLOGY

The unconsolidated deposits of Delaware County consist of luvium and glacial debris. The alluvial deposits are found ong White River, Mississinewa River, and the other main tri-tary streams. The glacial deposits cover the entire county d vary in thickness from 20 feet upward. An average of the icknesses of drift penetrated in 16 wells drilled for oil attered in various townships showed 54 feet of drift. It is finitely known that certain preglacial channels scoured out lleys. These valleys now contain greater thicknesses of drift.

The formations underlying the glacial drift in Delaware unty are of Silurian age. The Niagaran limestones outcrop at merous places in this county. The exposures are confined iefly to the valleys of the Mississinewa and White rivers. e Huntington dolomite is believed to underlie the drift along e eastern margin of the county. The Liston Creek limestone

is the bedrock over the remainder of the county with outcrops of Mississinewa shale along White River from a few miles east of Yorktown to the western boundary of the county.

Generalized Geologic Section for Delaware County

Quaternary:	
Recent, -- chiefly alluvial deposits	0- 25'
Pleistocene, -- glacial deposits	0-150'
Silurian:	
Huntington, -- dolomite (May underlie drift in eastern part of county, but not exposed)	
Liston Creek, -- limestone	20- 25'
Mississinewa, -- shale	(Thickness unknown)
Ordovician:	
(No outcrops. Reported from well records)	

GROUND WATER

Supplies of ground water may be obtained in Delaware County from either deep or shallow sources. Artesian waters occur in the Pleistocene deposits and in some of the deeper bedrock horiz Wells are ordinarily obtained at depths of 20 or 30 feet, either in gravelly deposits near the base of the drift or in the upper part of the limestone. Usually it is not necessary to sink deep wells to secure enough water for private supplies. Near Wheelin in the northern part of the county, wells are frequently drilled to depths of 50 feet without entering rock. At Muncie, Shideler and Eaton, wells enter rock at 15 to 25 feet. At Daleville the drift is 85 feet, but wells are obtained in sand below the till at 12 to 30 feet.

The Liston Creek limestone of Silurian age is the bedrock formation over most of Delaware County and is the chief bedrock aquifer. The upper surface where exposed to the drift is quite porous and with joint and bedding planes together with solution channels is capable of holding enormous quantities of water. A the Mississinewa shale which underlies the Liston Creek is rathe impervious, which fact explains the retention of water in the Liston Creek limestone. The bedrock formations of this county i to the eastward.

Delaware County has experienced considerable drilling for oil and gas since 1886. The producing horizon is known as the upper portion of the Trenton of the Ordovician. This horizon usually bears salt water, so deep wells will bear water unfit for use. The Trenton waters were artesian and in many instance rose in the drilled wells to pollute fresh water strata higher in the geologic column. Improper casing and plugging of wells assisted in the pollution. In recent years this trouble has about disappeared and for the most part the Silurian strata bea potable waters everywhere in the county.

When first settled Delaware County had considerable swamp areas, showing that the water table was high. In recent years artifical drainage has removed the water with a consequent lowering of the water table.

Water Supplies of Towns in Delaware County

Muncie. -- (population 46,548) The city of Muncie is furnished water by the Muncie Water Works Company, a private corporation. They have eighteen wells which are reported to be producing water from bedding planes in limestone rock. In addition a portion of the supply is taken from the West Fork of White River and treated chemically for use.

Albany. -- (population 1,413) The town of Albany is supplied water from tubular wells, by private ownership.

Selma. -- (population 344) The town of Selma has no public water supply.

Yorktown. -- (population 909) The town of Yorktown is supplied water from tubular wells, privately owned.

Eaton. -- (population 1,273) The town of Eaton owns its water supply, which is obtained from tubular wells.

Gaston. -- (population 654) The town of Gaston has no public water supply.

Typical Wells of Delaware County

Location	Depth	Quality	Quantity	Formation	Construction
19N-R9E					
Sec. 3	20'	Hard	Good	Gravel	Driven
Sec. 22	30'	"	"	"	Driven-Cross Road
20N-R9E					
Sec. 6	100'	"	"	Limestone	Drilled
Sec. 17	20'	"	"	Gravel	Driven
Sec. 27	Old Gas Well	"	"	Limestone	Drilled-Yorktown
21N-R9E					
Sec. 15	150'	"	"	Gravel	Driven
22N-R9E					
Sec. 34	60'	"	"	"	Driven-Gaston
Sec. 36	20- 30'	"	"	"	Driven
21N-R10E					
Sec. 2	60'	"	"	Limestone	Drilled-Shideler
Sec. 4	15- 25'	"	"	Gravel	Driven
21N-R11E					
Sec. 23	150-200'	"	"	Limestone	Drilled
Sec. 28	33'	"	"	Gravel	Driven-DeSoto
19N-R11E					
Sec. 14	50- 75'	"	"	"	Drilled
Sec. 26	20'	"	"	"	Driven
19N-R10E					
Sec. 16	90'	"	"	"	Drilled
Sec. 33	20'	"	"	"	Driven

D U B O I S C O U N T Y

GENERAL FEATURES

rea 427 square miles Population 20,553 (Census of 1930)

Dubois County is located in southwestern Indiana. It is the econd county north of the Kentucky-Indiana State line, and the hird county east of the Illinois-Indiana State line. Jasper is he county seat.

With the exception of the very northwestern corner, Dubois ounty is located within the driftless area of southern Indiana considerable area in the northwestern part of the county was at ne time a glacial lake bed, thus a fairly level topography exists oday. A few hills of preglacial origin rise above the general evel, though most of the area is mantled with alluvial and lacial sediments. In general the topography of Dubois County is ery broken, especially in the eastern portion, where the hills ise 75 to 200 feet above the valleys. This same condition prevails in the southwestern part of the county, though the hills ave more gentle slopes. "High hills, narrow winding ridges and teep bluffs with rock exposures in the eastern and southern ortions of the county, with level plains and rolling uplands, haracterize the topography of the county."

Drainage. -- The Patoka River and its tributaries gather the urface waters from a large part of Dubois County. This stream ontains many short meanders and the movement of the water is low. Its southern and eastern branches are responsible for the rainage of that portion of the county lying south and east of hat stream. Some small tributaries of Little Pigeon Creek, a ributary of the Ohio, drain a small area of the southwestern ortion of the county. Anderson River has some small branches raining a small area in the southeastern portion of the county. few short branches of the East Fork of White River drain the orthwestern part of the county. The East Fork of White River is he north boundary of the county for about 15 miles.

GEOLOGY

The unconsolidated deposits of Dubois County consist of luvial materials in the Patoka and White River bottoms, the acial sediments belonging chiefly to the part of the old glacial ake in the northwestern part of the county and to the till found n higher elevations between the White River bottoms and the toka Lake plain. In addition residual materials have accumulated as a result of weathering and disintegration of the underlying rmations. There are considerable areas of level land along the ourses of streams in Dubois County due to the damming of the reams by the ice front in glacial times and the deposition of he sediments in the laked portion. In these areas the

construction of ditches for the carrying away of the accumulated surface waters has been necessary.

The bedrock formations of Dubois County consist of strata of Mississippian and Pennsylvanian age. Some of the Chester formations of Mississippian age outcrop on the eastern edge of the county, however, occupy only a narrow belt. A few inliers of Chester occur within the area of the Pennsylvanian outcrop farther westward, but are exposed in areas low topographically.

The Pottsville Series of the Pennsylvanian underlie most of Dubois County. The overlying Allegheny Series are found in a belt about four miles in width along the western margin of the county. The Allegheny Series occupy about 80 square miles.

The Pennsylvanian strata consist of coals, shales, sandstones, and clays. The Mansfield sandstone, which is the basal portion of the Pennsylvanian has been quarried at several places in Dubois County.

Generalized Geologic Section for Dubois County

Quaternary:	
Recent, -- chiefly alluvium	0- 50'
Pleistocene, -- glacial drift, lacustrine deposits	0- 50'
Pennsylvanian:	475'
Allegheny, -- shales, coals, sandstone, limestones, clays	75'
Pottsville, -- shales, coals, sandstones, clays	400'
Mississippian:	
Chester	400'
Meramec, Osage, Kinderhook, (Not exposed)	
Devonian: (Not exposed at surface) Recognized in well logs	

GROUND WATER

There are five incorporated cities and towns in Dubois County. Two of these obtain municipal water supplies from impounding reservoirs and one from the Patoka River, the other have no public water supplies. This gives some indication of the water situation in this county insofar as securing public supplies is concerned. Only the northwestern corner of the county is within the glaciated area. This glaciated portion is largely in the valley flat along White River. A larger area in this county was at one time an old glacial lake bed and ground water is fairly easy to obtain in the lacustrine deposits.

Many private wells in the county obtain water from wells. The Pennsylvanian formations usually contain ground water in most areas, though in some areas the water is mineralized. The Mansfield sandstone underlies most of this county and where penetrated has furnished potable water.

Logan [107] gives the following log of a well drilled in

(107) Logan, W. N., The Sub-Surface Strata of Indiana, Publication No. 108, Dept. of Conservation, State of Indiana, 1931, p. 122.

Section 27, Township 1 North, Range 4 west, known as the Kellerville Oil well. Surface Elevation 600 feet.

Surface	0 to 15'
Sand, fine, WATER	45'
Shale, blue	80'
Limestone	90'
Sand	120
Limestone, broken	130
Shale, blue	175
Limestone, broken	190
Limestone, hard	195
Shale, blue	216
Limestone, white sandy	258
Sandstone, WATER	265
Hard gray limestone	303
Limestone, broken	355
Shale, soft	373
Sandstone, soft WATER	406
Limestone, gray, hard	420
Shale	453
Limestone	468
Shale, brown	483
Limestone, hard	506
Shale, blue	531
Sandstone	536
Sandstone-Gastat 582	948
Shale, sandy lime	961
Sandstone, dry gray sand	976
Limestone, gray	1011
Shale, limy	1021
Limestone, gray	1104
Sandstone, WATER	1121
Limestone, gray, sandy	1126
Sandstone, white-WATER	1136
Limestone, white, sandy	1191
Limestone, hard	1216
Limestone, sand	1226
Shell, hard	1231
Limestone, hardy sandy, WATER	1261
Limestone, gray, hard	1311
Sandstone, gray, hard	1318
Limestone, gray, sandy	1363
Shale, black limy	1370
Shale, gray	1500
Sandstone, gray	1515
Shale, gray	1540
Limestone, gray	1560
Shale, gray	1565
Shale, black	1584
Shale, very black	1670
Limestone	1925
Total Depth	1925

In this well there were recognized at least six water bearing horizons. Frequently in drilling wells for oil and gas, unless a string of casing is run to shut off each flow of water when penetrated, or unless the water rises perceptibly in the hole, all the water-bearing strata are not recognized. No records were kept as to the quality of the waters.

Water Supplies of Towns in Dubois County

Jasper. -- (population 3,005) The city of Jasper owns its water supply system. The source of water is the Patoka River. A complete treating system is in operation.

Holland. -- (population 323) The town of Holland has no public water supply. It is located in the southwestern part of the county, on strata of the Allegheny series. Strata of Pottsville age outcrop in Pokeberry Creek, just to the west of the town.

Ferdinand. -- (population 846) The town of Ferdinand obtains water from a municipally owned reservoir.

Birdseye. -- (population 366) The town of Birdseye has no public water supply.

Huntingburg. -- (population 3,440) The city of Huntingburg owns a surface reservoir from which the public water supply is obtained.

E L K H A R T C O U N T Y

GENERAL FEATURES

rea 462 square miles Population 68,875 (Census of 1930)

Elkhart County is in extreme northern Indiana on the lichigan-State line. It is the third county west of the Ohio-ndiana State line and the fifth county east of the Illinois-ndiana State line. Goshen is the county-seat.

Elkhart County has a topography of great diversity. The aximum relief of the county is 515 feet. The maximum local elief is 225 feet. The altitudes in the county range from 710 eet to 1,025 feet above sea level. The drainage of Elkhart ounty is controlled by St. Joseph River and its tributaries. he St. Joseph enters the county from the north, near Bristol, nd, flows somewhat south of west as far as Elkhart, then turns est and leaves the county. The river occupies a rather wide lluvial valley, however, the immediate river channel is narrow nd constricted. Baugo Creek, a southern tributary of the St. oseph River drains the south estern part of the county. Elkhart iver flows across the county from southeast to northwest and oins the St. Joseph at Elkhart. Little Elkhart River drains a ortion of the eastern part of the county. Yellow Creek rises n Yellow Pond and flows northward to join the Elkhart River outh of Elkhart. The southeastern part of the county is drained y Solomons Creek. The northern part of the county has Christiana reek and other small creeks draining directly into the St. Joseph iver.

Along the river valleys the county is low. This is ex-ecially true north of the St. Joseph River. The low flat area xtends to the Michigan line. There are several small lakes in his county. They are kettle lakes and occupy depressions in the oraines.

GEOLOGY

The unconsolidated deposits of Elkhart County consist of lluvium along the valley flats of the several streams, outwash lain deposits, terminal moraines and ordinary till. All of the ounty has been glaciated, however, a considerable portion of it as been modified by water action as the glaciers receded. St. oseph River has an alluvial valley flat 3 to 5 miles in width, lso the Elkhart River has abundant alluvial deposits bordering he stream. Over half of this county is occupied by terminal oraines. The area adjoining the moraines on the north, and outh of the alluvial valley flats is mantled with outwash plain posits. The material has been moved out from the parent drift. he glacial drift varies from 100 to 200 feet in thickness.

The bedrock strata of Elkhart which immediately underlie the glacial drift consist of Mississippian system rocks, with perhaps about 20 square miles in the very southwestern corner of the county underlain by Devonian shales.

The following is the general order of the deposits at Elkhart, down to the Devonian limestone:

	Thickness in feet	Depth in feet
Soil	5	5
Sand and gravel	29	34
Blue clay (Till)	88	122
Gray shale	213	335
Devonian shale	215	550
Devonian limestone		

The Mississippian (Borden group) formations underlie the glacial deposits.

GROUND WATER

The alluvial deposits of Elkhart County have considerable area and are of great importance as aquifers. The alluvial flat of the St. Joseph River is from 3 to 5 miles in width. Elkhart River also has a wide valley flat. Good flows of water are usually obtained at shallow depths in the alluvium and it is not necessary to penetrate the underlying glacial clay.

The moraines have a greater surface area than any other type of deposits in Elkhart County. Water is usually fairly easy to obtain from the morainal areas.

The outwash plain deposits usually contain an abundance of water, which can be obtained at shallow depths.

The till contains water, however, the clayey portions do not transmit water readily. Wells of large diameter are necessary if the supplies are to be sufficient for heavy demands for farm or household use.

The bedrock strata of Elkhart County, consisting of Borden siltstones and shales, together with the New Albany shale are not aquifers. They contain water but will not supply water in quantities demanded by the average well user. In many cases the water from these formations is salty or otherwise unfit for use. It is likely that deeper wells which would penetrate the Devonian limestones would obtain potable supplies of water in sufficient quantities. Frequently a well which obtains water from a deeper horizon will supply sufficient water for a domestic supply or farm supply, but not sufficient water for a public supply. It is also a fact that one individual or private owner cannot afford

drill such a deep well, whereas a muncipality can meet the required expenditure, but cannot expect to obtain water in sufficient volume. In either case the deep supply is impractical.

Water Supplies of Towns in Elkhart County

Elkhart. -- (population 32,949) The Elkhart City Water Works obtains a water supply from ten wells. The following summary has been given by Mr. J. R. Stephenson, Superintendent of the City Water Works.

Well No.	Diameter	Depth	Date Installed	Type	Yield
.	28'4"	31'5"	1891	Dug	1,000,000 G.P.D
.	39'	31'4"	1897	Dug	2,500,000 G.P.D
.	38'6"	30'6"	1899	Dug	1,500,000 G.P.D
.	41'	28'	1901	Dug	To reinforce No. 2
.	23'8"	15'7"	1907	Dug	To reinforce No. 3
.	16"	59'	1923	Drilled	1,500,000 G.P.D
.	26"	43'	1927	Drilled	1,440,000 G.P.D
.	26"	45'	1927	Drilled	1,500,000 G.P.D
.	26"	47'	1927	Drilled	1,500,000 G.P.D
.	26"	52'	1927	Drilled	1,500,000 G.P.D

The St. Joseph River flows in a broad valley of alluvium, which reaches its greatest width at Elkhart. Extending north from the alluvial valley of the St. Joseph at Elkhart is a broad outwash plain which gradually rises to the morainal ridges in the vicinity of Cass County, Michigan. This outwash plain permits ground water to move toward the St. Joseph River. At Elkhart, the wells for the city supply drilled in 1927 show approximately 50 feet of sand and gravel above the glacial clay. Other wells drilled north of the St. Joseph River find a similar section and get an abundance of water.

Mr. Stephenson is quoted as follows:

"With reference to the probable lowering of the ground water level in this vicinity, will state that we do not believe that such lowering has occurred. From a study of the geological formations, in which our wells located, it seems improbable that such could occur. The five dug wells installed a number of years ago, as listed in the foregoing sheet, were spaced an average distance of 250 feet apart, and during peak periods of water consumption, during the hot summer months, the draw down on these wells was very serious, and from the close spacing, a great deal of interference between the suction wells was evident. The test of the four new drilled concrete wells, installed during 1927, showed practically no interference. At the rate of 2,300,000 gallons per day pumpage from three of these wells, pumpage being coincident, the cone of depression from measuring points established at fifty foot intervals in line with the different wells, showed a depression at the half way point of one and one-half feet."

Wells at Elkhart drilled into the glacial till underlying the alluvium obtain small quantities of water. The wells which penetrate the gravels of the alluvium and drift obtain an abundance of water.

Goshen. -- (population 10,397) The city of Goshen obtains a municipal water supply from ten wells which produce from the coarse gravels. Bedrock is found at 140 feet.

Middlebury. -- (population 656) The town of Middlebury obtains a water supply from two wells, 8 inches in diameter. They are reported to be 118 feet in depth. Information was wanting concerning the producing horizon, but it is believed to be glacial drift.

Nappanee. -- (population 2,957) The town of Nappanee has three drilled wells, which penetrate 160 feet into drift. Water stands at 40 feet below the curb.

Bristol. -- (population 699) Bristol is located in the St. Joseph River valley flat and the wells secure an abundance o good water from 15 to 25 feet. They report a never failing supp

Millersburg. -- (population 344) The town of Millersburg is situated on a low moraine in the southeastern part of the county. One well, eight inches in diameter, supplies water from the glacial gravels. The well is 40 feet deep. The depth to bedrock is unknown as abundant supplies of potable water occur in the drift.

Wakarusa. -- (population 973) The town of Wakarusa obtains a public water supply from six wells drilled into glacial gravel Water stands from 10 to 20 feet below the curb. An abundant supply is reported. Wells in the town vary from 15 to 165 feet in depth.

Typical Wells in Elkhart County

Location	Depth	Quality	Quantity	Formation	Constructio
T35N-R4E					
Sec. 24	10-140'	Hard	Good	Gravel	Drilled
Sec. 34	80'	"	"	"	"
Sec. 36	150'	"	"	"	
T35N-R5E					
Sec. 3	70- 80'	"	"	"	"
Sec. 3	150-160'	"	"	"	"
Sec. 10	20'	"	"	"	"
T35N-R6E					
Sec. 26	20-160'	"	"	"	Driven & Drilled
Sec. 27	32'	"	"	"	Driven
Sec. 34	34'	"	"	"	"
T35N-R7E					
Sec. 4	20'	"	"	"	"
Sec. 6	13- 20'	"	"	"	"

Location	Depth	Quality	Quantity	Formation	Construction
T36N-R7E					
Sec. 9	15'	Hard	Good	Gravel	Driven
Sec. 15	100'	"	"	"	Drilled
Sec. 16	35'	"	"	"	Driven
Sec. 16	73'	"	"	"	Drilled
Sec. 17	35'	"	"	"	Driven
Sec. 18	29'	"	"	"	"
Sec. 21	173'	"	"	[illegible]	Drilled
Sec. 28	14'	"	"	Gravel	Driven
T37N-R7E					
Sec. 10	20- 30'	"	"	"	"
Sec. 15	80'	"	"	"	Drilled
Sec. 18	118- 64'	"	"	"	Driven & Drilled
T37N-R6E					
Sec. 10SE¼	160'	"	"	"	Drilled
Sec. 10SW¼	20'	"	"	"	Driven
Sec. 15	80'	"	"	"	Drilled
T37N-R5E					
Sec. 14	14'	"	"	"	Driven
Sec. 18	22'	"	"	"	"
Sec. 31	108'	"	"	"	Drilled
Sec. 32	68'	"	"	"	"
Sec. 32	110'	"	"	"	"
T36N-R5E					
Sec. 3	60- 80'	"	"	"	"
Sec. 7	100'	"	"	"	"
T37N-R5E					
Sec. 12	10- 20'	"	"	"	Driven
Sec. 7	10- 20'	"	"	"	"
T37N-R5E					
Sec. 4	25- 35'	Medium	Abundant	"	Dug & Driven
T36N-R6E					
Sec. 10	24- 36'	"	"	"	Dug & Driven
T36N-R5E					
Sec. 31	160'	"	"	"	Drilled
T34N-R4E					
Sec. 36	15-165'	"	"	"	Driven & Drilled
T37N-R7E					
Sec. 10	20-150'	Hard	"	"	Driven & Drilled
T38N-R6E					
Sec. 26	25- 30'	"	"	"	Dug & Driven
T36N-R7E					
Sec. 34	28- 65'	"	"	"	" " "
T38N-R6E					
Sec. 15	10- 20'	"	Fair	"	" " "
T37N-R5E					
Sec. 25	15- 30'	Soft	"	"	Driven
T35N-R5E					
Sec. 2	60-125'	Hard	Abundant	"	Driven & Drilled
T37N-R4E					
Sec. 26	25- 65'	"	"	"	Driven & Drilled
T35N-R4E					
Sec. 24	25-110'	"	"	"	Driven & Drilled

Location	Depth	Quality	Quantity	Formation	Constructi
Sec. 36	10- 50'	Hard	Abundant	Gravel	Driven & Drilled
T36N-R5E Sec. 34	45-135'	"	"	"	Driven & Drilled
T38N-R7E Sec. 16	20- 30'	"	"	"	Dug & Driven
T36N-R6E Sec. 27	10- 20'	"	"	"	Dug & Driven

CHEMIDAL ANALYSES OF ELKHART COUNTY WATERS (108)
(Parts per million)

Location	Geological Conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
Elkhart	Gravel	15	2.5		68	4.3	3.9		99		23	6.1		.000	2	234
Elkhart	"	10	0.5		46	21	6.3		12	182	9.2	2.0	0.6			221
Elkhart	"		.10		29	11				231	12	52	.40			254
Elkhart	"		2.0		67	19	4.7		129		33	3.2	.00			
Elkhart	"		2.7		71	18	8.8		132		41	3.9	.00			
Elkhart	"		1.5		59	18	3.5		121		22	2.8	1.5			
Elkhart	"		1.5		57	17	2.0		116		17	3.0				
Elkhart	"		1.5		53	20	5.5		125		15	3.8	.00			
Elkhart	"		1.2		61	18	5.8		132		17	1.9				
Elkhart	"		1.5		97	23	16.0		157		73	25				
Elkhart	"			.98	66	19	4.2		141		12	4.6				
Elkhart	"		1.2		73	20	10.0		148		26	7.9				
Goshen	"		1.5		55	19	2.9		118		16	4.5	4.0			
Goshen	"		2.9		67	22	2.5		141		18	3.8	4.5			
Goshen	"	18	0.2		50	21	8.2		11	198	15	1.8	Tr.			240
Goshen	"		.01		76	19			0	239	66	11	2.0	.001	2	370
Goshen	"		.01			28			.0	334	564		3.5		4	
Millersburg	"		.00		93	38			.0	306	46	20	8.0	.00	9	484
Nappanee	"		1.00		76	36			.	365	46	28	.30	.00	9	380
New Paris	"		.10		89	30			.0	263	101	260	6.00	.00	4	412
Wakarusa	"		.10		74	27			.0	291	107	12	.10	.00	2	362

(108) From Water-Supply paper No. 254, p. 109.

REPORT ON EXAMINATION OF WATER SUPPLIES, ELKHART, INDIANA

January 16, 1929.

Water from City Wells, Elkhart Municipal Waterworks

MINERAL SUBSTANCES

	Parts per million	Grains per U. S. Gal.
Silicon	14.8	0.88
Iron	0.1	0.006
Alumina	2.1	0.13
Calcium	55.2	3.31
Magnesium	21.3	1.28
Sodium	4.3	0.26
Bicarbonates	248.8	14.92
Carbonates	0.0	0.00
Chlorides	6.0	0.36
Sulphates	20.5	1.23
Nitrates	1.0	0.06
TOTAL SOLIDS	254.0	15.24

MINERAL SALTS:- (Hypothetical)

Iron bicarbonate	0.0	0.00
Calcium "	223.6	13.41
Magnesium "	96.5	5.79
Sodium "	0.0	0.00
Calcium sulphate	0.0	0.00
Magnesium "	25.7	1.54
Sodium "	0.0	0.00
Calcium chloride	0.0	0.00
Magnesium "	0.0	0.00
Sodium "	9.9	0.60
Sodium nitrate	1.4	0.08
Uncombined & Insol.	17.0	1.02

HARDNESS:- (In terms of Calcium Carbonate, $CaCO_3$)

Due to lime salts	138.0	8.28
Due to magnesia salts	87.2	5.23
Due to iron salts	0.0	0.00
TOTAL HARDNESS	225.2	13.51
TEMPORARY HARDNESS	203.9	12.23
PERMANENT HARDNESS	21.3	1.28

REPORT ON EXAMINATION OF WATER SUPPLIES, ELKHART, INDIANA

January 16, 1929.

Water from Foster Machine Co. Well, W. Beardsley Ave.

MINERAL SUBSTANCES

	Parts per million	Grains per U. S. Ga
Silicon	24.3	1.45
Iron	1.0	0.06
Alumina	0.5	0.03
Calcium	49.8	2.98
Magnesium	28.6	1.71
Sodium	6.0	0.36
Bicarbonates	278.1	16.68
Carbonates	0.0	0.00
Chlorides	20.0	1.20
Sulphates	0.0	0.00
Nitrates	0.0	0.00
TOTAL SOLIDS	263.0	15.78

MINERAL SALTS:- (Hypothetical)

Iron bicarbonate	3.2	0.19
Calcium bicarbonate	201.7	12.10
Magnesium bicarbonate	148.9	8.93
Sodium bicarbonate	0.0	0.00
Calcium sulphate	0.0	0.00
Magnesium sulphate	0.0	0.00
Sodium sulphate	0.0	0.00
Calcium chloride	0.0	0.00
Magnesium chloride	14.5	0.87
Sodium chloride	15.2	0.91
Sodium nitrate	25.8	
Uncombined & Insol.		

HARDNESS: -(In terms of Calcium Carbonate, $CaCO_3$)

Due to lime salts	124.5	7.47
Due to magnesia salts	116.9	7.01
Due to iron salts	1.8	0.11
TOTAL HARDNESS	243.2	14.59
TEMPORARY HARDNESS	228.0	13.68
PERMANENT HARDNESS	15.2	0.91

REPORT ON EXAMINATION OF WATER SUPPLIES, ELKHART, INDIANA

January 16, 1929.

Water from Riverside Laundry Well, Rockfort Street

MINERAL SUBSTANCES

	Parts per million	Grains per U. S. Gal.
Silicon	19.8	1.18
Iron	1.3	0.08
Alumina	1.1	0.06
Calcium	115.7	6.94
Magnesium	19.3	1.15
Sodium	63.0	3.78
Bicarbonates	318.4	19.10
Carbonates	00.0	0.00
Chlorides	63.0	3.78
Sulphates	150.7	9.04
Nitrates	0.0	0.00
TOTAL SOLIDS	744.0	44.60

MINERAL SALTS:- (Hypothetical)

Iron bicarbonate	4.1	0.25
Calcium "	419.4	25.16
Magnesium "	0.0	0.00
Sodium "	0.0	0.00
Calcium sulphate	40.4	2.42
Magnesium "	95.4	5.72
Sodium "	68.2	4.09
Calcium chloride	0.0	0.00
Magnesium "	0.0	0.00
Sodium "	103.9	6.23
Sodium nitrate	0.0	0.00
Uncombined & Insol.	21.2	1.27

HARDNESS:- (In terms of Calcium Carbonate, $CaCO_3$)

Due to lime salts	288.6	17.31
Due to magnesia salts	79.2	4.75
Due to iron salts	2.3	0.14
TOTAL HARDNESS	370.1	22.20
TEMPORARY HARDNESS	261.2	15.67
PERMANENT HARDNESS	108.9	6.53

REPORT ON EXAMINATION OF WATER SUPPLIES, ELKHART, INDIANA

January 16, 1929.

Water from Christiana Creek, Elkhart, Indiana

MINERAL SUBSTANCES

	Parts per million	Grains per U. S. G
Silicon	17.2	1.03
Iron	0.1	0.006
Alumina	1.9	0.11
Calcium	41.8	2.50
Magnesium	16.1	0.97
Sodium	7.8	0.47
Bicarbonates	203.7	12.22
Carbonates	0.0	0.00
Chlorides	5.0	0.30
Sulphates	11.5	0.69
Nitrates	1.3	0.08
TOTAL SOLIDS	215.0	12.90

MINERAL SALTS:- (Hypothetical)

Iron bicarbonate	0.0	0.00
Calcium "	169.3	10.15
Magnesium "	91.5	5.49
Sodium "	0.0	0.00
Calcium sulphate	0.0	0.00
Magnesium "	3.9	0.23
Sodium "	12.4	0.74
Calcium chloride	0.0	0.00
Magnesium "	0.0	0.00
Sodium chloride	3.8	0.50
Sodium nitrate	1.8	0.11
Uncombined & Insol.	19.2	1.15

HARDNESS:- (In terms of Calcium Carbonate $CaCO_3$)

Due to lime salts	104.5	6.27
Due to magnesia salts	65.7	3.94
Due to iron salts	0.0	0.00
TOTAL HARDNESS	170.2	10.21
TEMPORARY HARDNESS	167.0	10.02
PERMANENT HARDNESS	3.2	0.19

REPORT ON EXAMINATION OF WATER SUPPLIES, ELKHART, INDIANA

January 16, 1929.

Water from St. Joseph River, Elkhart, Indiana

MINERAL SUBSTANCES

	Parts per million	Grains per U. S. Gal.
Silicon	18.7	1.12
Iron	0.1	0.006
Alumina	0.7	0.04
Calcium	54.3	3.25
Magnesium	13.7	0.82
Sodium	2.5	0.15
Bicarbonates	190.3	11.42
Carbonates	0.0	0.00
Chlorides	5.0	0.30
Sulphates	33.4	2.00
Nitrates	2.2	0.13
TOTAL SOLIDS	289.0	17.34

MINERAL SALTS:- (Hypothetical

Iron bicarbonate	0.0	0.00
Calcium bicarbonate	220.0	13.20
Magnesium "	29.5	1.77
Sodium "	0.0	0.00
Calcium sulphate	0.0	0.00
Magnesium "	41.8	2.50
Sodium sulphate	0.0	0.00
Calcium chloride	0.0	0.00
Magnesium chloride	1.6	0.09
Sodium chloride	6.3	0.38
Sodium nitrate	10.0	0.00
Uncombined & Insol.	19.5	1.17

HARDNESS:- (In terms of Calcium Carbonate, $CaCO_3$)

Due to lime salts	135.8	8.14
Due to magnesia salts	56.4	3.38
Due to iron salts	0.0	0.00
TOTAL HARDNESS	192.2	11.52
TEMPORARY HARDNESS	155.9	9.35
PERMANENT HARDNESS	136.3	2.17

FAYETTE COUNTY

GENERAL FEATURES

Area 216 square miles Population 19,243 (Census of 1930)

Fayette County is located in the southeastern portion of central-eastern Indiana. It is the fourth county north of the Indiana-Kentucky State line and the second county west of the Indiana-Ohio State line. Connersville is the county seat.

The greatest elevation in Fayette County is 1110 feet above sea level, the lowest is 695 feet, thus giving a total maximum relief of 415 feet. The maximum local relief is 250 feet. With the exception of a small area along the central portion of the southern boundary, all of Fayette County was covered by the two drift sheets. Two large morainal belts cross the county from north to south, trending slightly east of north. These morainal areas constitute over one-half of the surface area of the county. The West Fork of Whitewater River valley constitutes the dividing line between the belts of moraines. The valley averages about three miles in width. For the most part the general surface of the county is fairly level to rolling, with the valley of the West Fork of the Whitewater being the prominent topographic feature of the county. The bluffs along the river valley in some cases rise to as much as 200 feet above the river level.

Drainage.-- The extreme northwestern portion of Fayette County is drained by some small tributaries of the East Fork of White River. The remainder of the county is drained by the West Fork of Whitewater River and its tributaries. Sains Creek in the southwestern part of the county flows southeastward and joins the Whitewater near Laurel. Garrison Creek, Fall Creek, and Williams Creek are branches flowing into the Whitewater River from the northwest. They drain the central and western parts of the county. Lick Creek aids the Whitewater in draining the northern part of the county. Village Creek and Bear Creek are westwardly flowing branches of the West Fork of Whitewater River. They drain a portion of the eastern part of the county.

GEOLOGY

The unconsolidated deposits of Fayette County consist of alluvial materials, chiefly along the Whitewater River and major tributaries. The Whitewater River has a gravel plain on either side which varies in width from one to two miles. This gravel plain is chiefly outwash materials, carried away by melting ice waters from the front of the Wisconsin ice sheet. In the upland areas of the county rock is seldom found in wells at depths under 50 feet and in most places the glacial drift is approximately 100 feet in thickness. The drift is a compact till, though sand and gravels are associated with the till.

The bedrock formations of this county are of Ordovician and Silurian age. The eastern two-thirds of the county is underlain by Ordovician strata, the western one-third is underlain by Silurian strata. There are many outcrops of the formations along creeks and rivers. Stone has been quarried at a number of localities in Fayette County.

Generalized Geologic Section for Fayette County

Quaternary:	
Recent, -- alluvium	0- 25'
Pleistocene, glacial drift, glacial outwash .	0-100'
Silurian:	50'
Ordovician:	
Cincinnatian, -- limestone and shales	600'

GROUND WATER

The chief source of water in Fayette County is the glacial drift, both for public and private supplies. The drift ranges from a few feet to as much as 100 feet in depth. At Connersville wells are reported to penetrate bedrock at 99 feet. In the valley of Whitewater River abundant supplies of water are obtained from the outwash gravel and flood plain deposits.

Tucker (109) has described a portion of the Whitewater valley as follows:

(109) Tucker, W. M., Hydrology of Indiana, Part III, Handbook of Indiana Geology, Dept. of Conservation Publication No. 21, State of Indiana, 1922, pp. 308-309.

"White Water valley is situated in the rocks of the Cincinnati series. The west bluff of the west branch, throughout its course above Metamora, is capped by a considerable thickness of limestone of Silurian age(Brassfield a Niagara). The Niagara forms a distinct divide parallel to an just west of the west branch, along its upper course. The cr of this divide forms the western edge of the Whitewater basin This condition causes the western tributaries of the west bra to be very short and very swift streams."

The Cincinnatian rocks of the Ordovician are composed chiefly of limestones and shales. They are not aquifers, but the limestones would produce sufficient water for home or farm use where deeper wells are drilled into them. Usually cisterns, springs, and wells drilled into the drift supply th demands, so deeper wells are unnecessary. The contact of the drift and the bedrock is an excellent water horizon.

The Silurian limestone strata are ordinarily good water bearers and in Fayette County would obtain water from the drift.

Water Supplies of Towns in Fayette County

Connersville. -- (population 12,795) The city of Connersville has its own water plant. The source consists of five wells drilled from 42 to 80 feet into gravels of Whitewater River valley. This should afford an excellent supply. Bedrock is reported at 99 feet.

Glenwood. -- (population 374) The town of Glenwood has no public water supply. The population of Glenwood is divided as follows: 106 in Fayette County, 268 in Rush County. Private wells obtain water at depths ranging from 20 to 50 feet. Years ago a well drilled for gas in this vicinity penetrated 120 feet of drift. The upper 60 to 70 feet were logged as till, the remainder as sand and gravel. Large supplies of water of excellent quality should occur in the deeper sands and gravels.

F L O Y D C O U N T Y

GENERAL FEATURES

Area 148 square miles Population 34, 655 (Census of 1930)

Floyd County is situated in the southeastern portion of central-southern Indiana, on the Ohio River. New Albany is the county seat. The greatest altitude in Floyd County is 1.020 feet above sea level, the minimum is 370 feet above sea level, thus giving a total maximum relief of 650 feet, the greatest of any county in the State. The maximum local relief is 560 feet, being exceeded only by the figure in Harrison County which is 610 feet. Harriosn County joins Floyd on the west.

The county is included in three physiographic provinces. The eastern portion is a part of the Scottsburg Lowland, the central portion is included in the Norman Upland and the western part is embraced in the Mitchell Plain. The central portion is the most prominent from a topographic standpoint. It is characterized on the east by the Knobstone Escarpment, the most prominent relief feature of the State. Most of Floyd County is very hilly and naturely dissected by stream action. East of the main divide the surface descends rather abruptly to the Ohio River. Most of the streams on the eastern margin of the county are short. They flow intermittently. The western slope of the county is more gentle and the headwaters of Indian Creek have broad valleys. As all the streams have fairly steep gradients the amount of bottom land is limited. The eastern portion of the county has some low land located between the "Knobs" and the valley of Silver Creek in adjacent Clark County.

Drainage. -- The eastern portion of Floyd County is drained by Silver Creek and a few of its westerly extending branches. The most important of these is Falling Run Branch. The main part of the county is drained by Indian Creek and its tributaries. Yellow Fork and Middle Fork unite in the western part of the county to form Indian Creek which flows in a southwesterly direction to enter the Ohio River in western Harrison County. Middle Creek flows south in the region of New Albany to enter the Ohio. Kob Creek rises in the northern part of Franklin Township and flows southward into the Ohio River.

GEOLOGY

Floyd County lies within the unglaciated portion of Indiana. The northeastern corner of the county touches the outermost margin of the Illinoian drift. Silver Creek, in adjacent Clark County may have modified the original drift burden somewhat in the extreme eastern corner of the county, though alluvial deposits of Silver Creek now cover the area. The streams of the county have steep gradients, therefore, little deposition of alluvial material has occurred.

The bedrock strata of Floyd County consist of Devonia and Mississippian rocks. The Devonian underlie the valley flat west of Silver Creek and also are in the Falls of the Ohio. The Mississippian rocks outcrop through the remainde of the county and are responsible in large measure for the rough topography. The Borden, formely called Knobstone is bedrock in the region known as the "Knobs". It underlies la areas of the county. The surface irregularities of Floyd Co are caused by the dissection of soft shales of the Borden gr whose firm upper layers have resisted erosion. The Borden, Harrodsburg, Salem, and St. Louis formations outcrop from we to east across the county.

Generalized Geologic Section for Floyd County

Quaternary:		
	Recent, -- alluvium	0- 10'
	Pleistocene, -- terrace deposits	0- 25'
Mississippian:		
	St. Louis, --	100'
	Salem, --	40- 50'
	Harrodsburg, --	75'
	Borden, -- at Floyds Knob	505'
Devonian:		
	New Albany, -- shale -- Type Section . .	104'
	Middle Devonian (Beechwood limestone . .	2- 5'
	(Silver Creek limestone .	10- 15'
	(Jeffersonville limestone.	40'

Silurian: (Does not outcrop, reported from well logs.

GROUND WATER

The Ohio River, from New Albany south, has a bottom land averaging half a mile in width. This flood plain is a source of ground water, though, in extreme high water stage, the entire flood plain is inundated. Alluvial deposits occu also along some of the lower courses of smaller streams and at the bottom of steep slopes. Many of the springs flow an during wet weather.

The Borden outcrop belt is noted for scarcity of grou water, though the formations serve as foundations for reser and ponds. Several springs of small flow issue from Borden formations where the underlying formation is an ipmervious s The contact between the Borden and Harrodsburg is a spring horizon, also the contact between the Harrodsburg and Sale Where the surface formations have been deeply dissected as in Floyd County, it is not probable that the Mississippian lime stones could contain much water.

Floyd County has a small area, and contains outcrops b the New Albany shale and the Borden group. Both are relati

impervious. The Harrodsburg, Salem, and St. Louis formations are chiefly limestones. Subterranean drainage develops to a certain extent, which with the draining by deep canyons does not permit water to accumulate in the strata. Cisterns, artificial reservoirs, stream waters, and shallow wells will continue to be the sources of water in Floyd County.

Water Supplies of Towns in Floyd County

Georgtown. -- (popluation 374) The town of Georgtown has no public water supply.

Greenville.-- (populations 257) The town of Greenville has no public water supply.

New Albany. -- (popluation 25,819) The Interstate Public Service Company supplies the city of New Albany with water obtained from the Ohio River. The water is treated chemically to remove sediments and for purification.

Typical Wells of Floyd County

Township	Section	Quality	Depth	Formation
Franklin	SE¼ 14-3-5	Soft	-----	Cistern
"	NE¼ 24-3-5	"	-----	"
"	Buchanan	----	15-25'	-------
Georgtown	SW¼ 19-2-5	----	Spring	Sandstone
"	SW¼ 19-2-5	----	12'	-------
"	SE¼ 19-2-5	----	Spring	Sandstone-Limestone
"	Georgtown	----	30-40',160	-------
"	NE¼ 2-3-5	Soft	-----	Cistern
"	NE¼ 6-3-5	----	30'	-------
Greenville	SE¼ 11-2-5	----	-----	Spring
"	Salena	----	14-22',54'	Shale & sandstone
"	SE¼ 4-2-5	----	13'	-------
"	Greenville,	Salt	126'	-------
"	" "	---	15-40'	-------
"	NE¼ 7-2-5	Hard	30'	Limestone
"	SE¼18-2-5	----	28-14'	Limestone
Lafayette	Floyd's Knobs	---	30'	Sandstone
"	NW¼13-2-5	Hard	80'	Limestone
"	NW¼13-2-5	Soft	30'	Sandstone
New Albany	NE¼29-2S-6W	Soft	-----	Cistern
" "	NE¼ 5-3-5	----	15'	-------
" "	SE¼ 4-3-5	----	12'	-------

F O U N T A I N C O U N T Y

GENERAL FEATURES

a 395 square miles Population 17,971 (Census of 1930)

Fountain County is located in central western Indiana. Its tern boundary is the Wabash River which at its closest point pproximately 5 miles from the Illinois-Indiana State line. It ic fifth county south of Lake Michigan.

The surface of the entire county is covered with glacial ft, which is very thick in some areas. In that portion of county lying north of Shawnee Creek, the surface is marked belt of moraines. The moraines, parallel the Wabash River, ugh are scarcely perceptible southwest of Shawnee Creek. The tral part of the county is an elevated plain with gentle ulations. In the extreme southeastern corner of the county, r Mill Creek has cut a deep gorge. The maximum altitude of ntain County is 780 feet above sea level, the minimum is 470 t, thus giving a total maximum relief of 310 feet. The maximum al relief is 150 feet.

Drainage. -- The Wabash River forms the northern and tern boundaries of Fountain County. All of the surface ers are carried to the Wabash by tributaries flowing north, t, and southwest. The northern part of the county is drained Big Shawnee Creek which flows in a generally westward direction o the Wabash. The central and southwestern portions are drained Coal Creek and its tributaries. Coal Creek enters the Wabash ut one mile south of the Fountain County line. The extreme theastern portion of the county is drained by tributaries of r Creek, which passes through the northern part of Parke nty to enter the Wabash.

GEOLOGY

The unconsolidated deposits of Fountain County consist glacial drift and alluvial deposits. The glacial drift ies from a few feet to over 100 feet in thickness. Eroded f ces and preglacial channels give rise to the irregularities thickness. The Illinoian and Wisconsin drift sheets covered entire county.

A preglacial channel of the Wabash River has been des- bed by R. T. Brown in the 11th Annual Report of the Indiana artment of Geology and Natural History. He reports that three miles south of the northeastern corner of the county lacial valley has been traced, which extends southwestward, t of Stone bluff; and a little northwest of Veedersburg, ssing Dry Run and Coal Creek near the junction of those ams and finally joining the present Wabash River at a point ut four miles below Covington. This valley of erosion has been cted by well drillers who report great thicknesses of glacial

drift, absence of coal strata where it is normally expected to occur, and great thicknesses of gravel in the old stream valley. In prospecting for coal, the borings often found bedrock within 30 or 40 feet of the surface, whereas just a few feet away, no coal or bedrock would be found unless the borings were carried ofttimes to depths of 100 or more feet.

The Wabash Valley in this part of Indiana is characterized by broad, valley flats. The banks are composed of river sediment and are not high. The bluffs back of the valley flat are in some places in Fountain County from 50 to 100 feet high. From Attica to Portland the Wabash River has cut into a conglomeratic sandstone from 25 to 40 feet and this sandstone forms a bluff. East of the bluff are found the glacial deposits which overlie c on top of the bedrock. The bluffs are formed by Pennsylvanian sandstones.

The bedrock formations which outcrop or underlie drift in Fountain County are of Mississippian and Pennsylvanian age. The Borden group of the Mississippian is believed to underlie about 80 square miles in the northeastern and eastern portions of the county. The Pottsville and Allegheny series of the Pennsylvanian underlie the drift in the rest of the county. Exposures of bedrock occur where streams have cut downward into them. The Allegheny series strata are found only in southwestern Fountain County, along Coal and Mill Creeks.

Generalized Geologic Section for Fountain County

Quaternary:	
Recent, -- chiefly alluvium	0- 50'
Pleistocene, -- glacial drift	0-150'
Pennsylvanian:	240'
Allegheny, -- sandstone, coal, shale, clay. . . .	
Pottsville, -- " " " "	
Mississippian:	
(Pottsville series overlaps on to Borden, Upper Mississippian not represented)	
Borden, -- (Few outcrops) Total thickness unknown.	500'
Rockford, -- limestone -- (Not recognized from well logs)	
Devonian:	
(No outcrops. Reported from logs)	
Silurian:	
(No outcrops. Reported from logs)	
Ordovician:	
(No outcrops. Reported from logs)	

There have been but very few deep wells drilled in Fountain County so little is known about the subsurface conditions.

GROUND WATER

The glacial drift is the chief source of ground water n Fountain County. Along the Wabash River bluffs, springs re fairly abundant, especially in the northern part of the ounty. The loose glacial materials rest on impervious clays r shales which give the proper conditions for gravity springs he drift is full of ground water, expecially the morainal reas. The clayey portions of the till contain water but do ot supply it readily to wells or as springs.

Many wells throughout the county penetrate the bedrock ormations for water supplies. The Borden strata will not urnish water, and their areal extent is small. The Pennylvanian formations contain sandstones and coals which are quifers. The basal Pennsylvanian is an excellent aquifer nd the Wabash Bluffs show the presence of a massive sandstone nderlying most of the county. This particular horizon should e very productive of water, though perhaps deeper than the rdinary farm well.

Fountain County has some mineral waters described by latchley in the 26th Indiana Department of Geology and atural Resources report. They are located at Lodi, Attica, nd near Wallace. The Wallace spring has chalybeate water and s reported to flow from glacial drift. South of this location long Sugar Mill Creek are a number of springs with iron-content n solution. At Attica a well penetrated a stratum containing aline-sulphur water at a depth of 600 feet. The Lodi well was rilled in 1865 to a depth of 1,155 feet. At 1.057 feet in a agnesian limestone, a strong flow of mineral water was penetrated. alt water occured at 1, 155 feet.

Throughout much of the county bedrock is penetrated at epths from 40 to 50 feet. Usually sufficient water is obtained from the drift or from the bedrock.

Water Supplies of Towns in Fountain County

Hillsboro. --(population 448) The town of Hillsboro as no public water supply.

Wallace. --(population 128) The town of Wallace has o public water supply.

Attica.-- (population 3,700) The city of Attica owns ts water supply, obtained from tubular wells. Nine wells roducing from bedrock reported as limestone furnish the supply. lowing artesian wells occur within the city.

Mellott. -- (population 312) The town of Mellot has no ublic water supply.

Kingman. -- (Population 502) The town of Kingman has o public water supply.

Newtown.--(Population 264) The town of Newtown has no ublic water supply.

Covington. -- (population 2,008) The city of Covington owns its water plant. Dug wells and one tubular well are the source of the water.

Veedersburg. -- (population 1.606) The city of Veedersburg has a municipal water plant obtaining water from four wells. Water stands within 20 feet of the surface.

F R A N K L I N C O U N T Y

GENERAL FEATURES

Area 394 square miles Population 14,498 (Census of 1930)

Franklin County is located in southeastern Indiana, adjacent to the Ohio-Indiana State line. It is fourth county north of the most southeastern portion of Indiana.

The county was covered by the Illinoian drift, however, the later drift sheet covered a small area in the northwestern and the northeastern corner of the county. The Wisconsin drift margin is marked by terminal moraines, though they are only sharp gravelly knolls and not prominent. This county is included in the Dearborn Upland and is characterized by extreme in relief. The maximum altitude in the county is 1,040 feet above sea level, the minimum is 525 feet, thus giving a maximum relief of 515 feet. The maximum local relief is 300 feet. The valleys are terraced by glacial outwash, especially prominent along the Whitewater.

Drainage. -- With a few exceptions the drainage of Franklin County is accomplished by Whitewater River. The two main branches of this stream unite less than one mile below Brookville. The eastern branch flows southward through Franklin County from Union County on the north end the western branch flows from Fayette County on the north and takes a southeasterly course later entering Franklin County. Small branches of the West Fork include Sains, Little Salt, Salt, Hodsons, Butts, and Harveys. All of these enter the West Fork from the west and southwest. The eastern branches of East Fork and the main stream include Templeton, Big Cedar, and Blue Creek. Two small tributaries of the Miami River drain a small area in the eastern part of the county. Some small tributaries of Laughery Creek drain the southwestern part of the county.

GEOLOGY

On the high uplands of Franklin County the glacial drift is frequently less than 10 feet in thickness. In the valley of Whitewater River the drift and outwash deposits are as much as 200 feet thick. Great thicknesses of the drift are to be expected in preglacial erosion channels and in filled tributaries of the Whitewater system.

The bedrock formations of Franklin County consist of strata of Ordovician and Silurian age. Ordovician rocks underlie most of the county, the Silurian being found only in the extreme western portion.

Generalized Geologic Section for Franklin County

Quaternary:	
Recent, -- alluvium and residual materials	0-50'
Pleistocene, -- glacial drift, outwash gravels	0-200'
Silurian:	50'
Ordovician:	585-657'

GROUND WATER

Ground water may be secured in Franklin County from the glacial drift, alluvial deposits and bedrock formations. Waters obtained from the surficial formations are generally potable. Where sufficiently thick and undrained the drift is an aquifer, but where remnants and scattered patches of drift are located on uplands, they are not water-bearing. The outwash gravels along Whitewater River are excellent sources of water. Most of the alluvial deposits along the streams furnish local supplies where wells are drilled into them.

The bedrock strata of this county are chiefly Ordovician in age and are not aquifers. They contain ground water in limited quantities but would not produce public supplies. Farmers depend on shallow wells, cisterns, ponds, and artificial reservoirs and streams. Waters from formations deeper down in the earth are likely to be mineralized.

Water Supplies of Towns in Franklin County

Brookville. -- (population 2,148) The city of Brookville owns its water supply, obtained from two wells producing from limestone, depth unknown. Natural springs are reported plentiful in the vicinity of Brookville. The location of the city, in the forks of the two branches of Whitewater River leads to the conclusion that the water source is the valley train and not the underlying limestone.

Laurel. -- (population 516) The town of Laurel owns one tubular well from which the town water supply is obtained.

Oldenburg. -- (population 575) The town of Oldenburg has no public water supply system.

Mt. Carmel. -- (population 150) The town of Mt. Carmel has no public water supply system.

Cedar Grove. -- (population 221) The town of Cedar Grove has no public water supply system.

FULTON COUNTY

GENERAL FEATURES

Area 367 square miles Population 15,038 (Census of 1930)

Fulton County is located in central northern Indiana, the third county south from the Michigan-Indiana State line and the fourth east of the Illinois-Indiana State line. Rochester is the county seat.

The maximum altitude of Fulton County is 900 feet above sea level and the minimum is 715 feet, thus giving a total maximum relief of 185 feet. The maximum local relief is 80 feet. The average altitude of the county is 760 feet, which is the average for the entire State of Indiana. A narrow belt of moraine crosses the western margin of the county. Lake Manitou, southeast of Rochester is located in a morainal area. The morainal topography is rolling and exhibits the typical kettle and hole features peculair to moraines. Tippecanoe River flows through the north section of the county. It has a valley flat consisting of alluvial materials, sands, gravels, and silts. The county has within its borders 24 natural lakes. The largest lake is Manitou, near Rochester. All of the lakes are in the morainal belts and occur in depressions of the moraines. The remainder of the county not composed of alluvial materials or moraines consists of gently undulating till plains.

Fulton County is drained by the Tippecanoe River and tributaries. In the southwestern part of the county Indian Creek flows westward into the Tippecanoe and Mill Creek which drains a portion of the south part of the county enters the parent stream northwest of the county line. Mud Creek which is a southern tributary of the Tippecanoe drains a large part of the southwestern part of the county. The eastern and southwestern portions are drained by small tributaries of the Tippecanoe.

GEOLOGY

The entire surface of Fulton County has been modified by glaciation. In addition certain changes in the topographic features have been made since the removal of the ice-sheet. The Tippecanoe River valley is covered at the surface with alluvial deposits consisting of gravel, sand, and silt. Dune deposits have been formed by wind action. Certain features of the river valley are probably fluvio-glacial in origin.

The morainal areas are of mild relief and consist of typical accumulations of sand, gravel, and associated till with boulders. The till plains are usually flat to undulating and the till in many places extends to 200 feet in depth.

The strata underlying the drift in Fulton County are of Silurian and Devonian age. The known distribution of bedrock has been determined from a study of well records. South of an eastwest line extending through the town of Kewanna, the bedrock is of Silurian age and north of this line they are Devonian. The drift rests on the eroded surface of these strata. The county is on the northeastern side of the Cincinnati arch. It is believed that the strata dip essential northward toward the Michigan basin. Owing to the paucity of well records little is known about sub-surface conditions of this county.

Generalized Geologic Section for Fulton County

Quaternary:
Recent, -- chiefly alluvial deposits . . . . . 0-50'
Pleistocene, -- glacial deposits . . . . . 100-200'
Devonian:
(Does not outcrop. Reported from well records)
Silurian:
(Does not outcrop. Reported from well records)

GROUND WATER

The alluvial deposits of Fulton County are of considerable areal extent in the Tippecanoe Valley and cover a part of the plain south of it. West of Rochester the alluvia sands have been shaped into dunes by the wind. In these alluvial areas, ground water is easily obtained at shallow depths. Driven wells and dug wells have been used very much.

In the morainal areas, the upper portions consisting of typical accumulations of gravel or sand for the most part bear water. Frequently it is necessary to penetrate the clay till sheet, which yields water but slowly. Bedrock is usually about 150 feet in depth. At Rochester a well boring logged 155 feet of drift. This well was at the court-house. A well located sixty rods northeast logged 245 feet of drift. At Kewanna the drift is 167 feet in one well and 208 in another. Where till outcrops at the surface, wells of large diameter usually give better results.

Bedrock has been penetrated at only a few places in the county. At Rochester and at Kewanna, the drift has been entirely drilled through into bedrock.

Wells drilled into the Silurian limestones in this county should obtain excellent water supplies. In the northe half of the county the first strata below the drift are thoug to be Devonian shales and would not be water-bearing, howeve deeper wells would penetrate Devonian and Silurian limestone which in this area should bear potable supplies.

The abundance of natural lakes in this county indicates hat the water table is near the surface and that ground water ill be obtained at relatively shallow depths.

Water Supplies of Towns in Fulton County

Akron. -- (popultaiom 932) Akron obtains a municipal ater supply from tubular wells. The system is city-owned.

Fulton. -- (population 397) The town of Fulton has o public water supply. Privately owned wells penetrate the rift. The water table is near the surface.

Rochester. -- (population 3,518) The city of Rochester wns its water system. The source of the water is tubular ells.

Kewanna. --(population 682) The town of Kewanna owns ts water system. Two wells drilled into glacial drift furnish he supply. The wells are 10 inches and 8 inches in diameter. ater stands at 15 to 30 feet below the surface in wells in his vicinity. Six miles northwest of Kewanna, artesian wells ccur near Lake Bruce, which is on the Fulton-Pulaski County ine.

Location	Depth	Quality	Quantity	Formation	Constructio
T29N-R1E					
Sec. 22	35-40'	Hard	Good	Gravel	Drilled
Sec. 23	41'	"	"	"	"
Sec. 24	100'	"	"	"	"
Sec. 24	50-100'	"	"	"	"
T29N-R2E					
Sec. 5	84'	"	"	"	"
Sec. 23	20-100'	"	"	"	Driven
T30N-R3E					
Sec. 29	40'	Medium	"	"	"
Sec. 88	15-80'	Hard	Abundant	"	Driven-Dril
T30N-R1E					
Sec. 27	150'	"	"	"	" "
T30N-R4E					
Sec. 22	20-60'	"	"	"	" "
T31N-R3E					
Sec. 9	25-50'	"	"	"	" "
T29N-R2E					
Sec. 23	30'	"	"	"	Dug " "
Athens	35-40'	"	"	"	Driven-Dril
T29N-R2E					
Sec. 19	25-35'	"	"	"	" "
T30N-R1E					
Sec. 9	23-150'	"	"	"	" "
T31N-R1E					
Sec. 16	25-55'	"	"	"	" "
T30N-R5E					
Sec. 33	12-43'	"	"	"	" "
T29N-R2E					
Sec. 32	60-100'	"	"	"	" "
T31N-R2E					
Sec. 32	10-30'	"	"	"	Driven
T29N-R1E					
Sec. 22	30-110'	"	"	"	Driven & Dr
T30N-R3E					
Sec. 34	40-60'	"	"	"	" '
T31N-R1E					
Sec. 23	35-60'	"	"	"	" '
T31N-R2E					
Sec. 2	90-195'	"	"	"	" '
Showley	50-75'	"	"	"	" '
T31N-R3E					
Sec. 9	12-40'	"	"	"	" '
T21N-R3E					
Sec. 2	15-170'	"	"	"	" '
Kewanna	150'			"	
Akron	20-60'			"	
Tiosa	25-50'			"	
Fulton	30'			"	
Athens	35-40'			"	
Blue Grass	26-35'			"	
Bruce Lake	23-150'			"	
Delong	25-55'			"	

ocation	Depth	Quality	Quantity	Formation	Construction
isko	12-43			Gravel	
lotcher	60-100'			"	
ermany	10- 30'			"	
rass Crook					
	30-110'			"	
reendak	40-60'			"	
oiters					
Ford	35-60'			"	
ichland					
Center	90-195'			"	
howley	50-75'			"	
alma	12-40'			"	
agoner	15-170'			"	

CHEMICAL ANALYSES OF PUBLIC [illegible]
(Parts per million)

Location	Geological Condition	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
Akron	Gravel		2.0		76	21			0.0	228	13	10	0.2	.001	4	272
Akron	Gravel		.2		87	19			0.0	25	58	30	16	.001	4	564
Delong	Gravel		2.4		73	24			.0	289	24	10	.10	.001	4	302
Disko	Gravel		1.9		99	29	16		191		66	9.1				
Fulton	Gravel		.01		144	39			.0	352	206	58	.010	.001	2	782
Kewanna	Gravel		.30		64	28			.0	261	84	4	.010	.00	2	388
Richland Center	Gravel		.04		84	34			24	241	15	9	.05	.00	4	384
Rochester	Lake	.05	1.0		57	17	2.3			111	22	9.2				
Rochester	Lake			.36	27	14	2.9		67		16	1.3				
Rochester	Lake		3		24	18			.0	121	27	2.0	.20	.001	42	218
Rochester	Gravel		2.8		87	20			.0	253	20	4.0	1.00	.020	4	310
Rochester	Gravel		.01		81	22			.0	204	0.9	8.0	.000	.00	13	364
Rochester	Limestone	18	.6		72	28	21		.0	382	8.2	3.0	.44			326
Rochester	Gravel	17	.9		84	24	5.6		.0	369	13.	2.0	.50			333
Talma	Gravel		.2		82	25			.0	295	9.9	2.0	.20	.00	4	354
Tiosa	Gravel		.04		126	35			.0	284	78	41.0	.10	.00	4	590

(110) From Water-Supply Paper No. 254, p. 116.

GIBSON COUNTY

GENERAL FEATURES

Area 486 square miles Population 29,202 (Census of 1930)

Gibson County is located in southwestern Indiana. Its western boundary is the Illinois-Indiana State line. It is the second county north of the Indiana-Kentucky State line. Princeton is the county seat.

The highest altitude in the county is 650 feet above sea level, the lowest is 355 feet, thus giving a maximum relief of 295 feet. The maximum local relief is 250 feet. The county lies within the glaciated area of southwestern Indiana, with the exception of the southeastern corner. A large portion of the unglaciated section of the county consisted of lakes during the Illinoain glacial epoch and was flooded by streams coming out of the driftless area. Physiographically the county is a portion of the Wabash Lowlands. The surface in the western part of the county is level or undulating, a large share of this area being bottom lands along the Wabash, White, and Patoka Rivers. Some of this bottom land is sandy and locally drifted into dunes. The eastern part of Gibson County is higher in elevation and consists of rugged uplands.

Drainage. -- The surface waters of Gibson County flow into White, Wabash, or Patoka rivers and their tributaries. White River is a tributary of the Wabash. It forms the boundary between Gibson and Knox Counties. The Patoka River enters the Wabash a few miles south of the confluence of the White and Wabash. It drains a large area in northeastern Gibson County. The Patoka enters the county near the northeasternmost corner and flows entirely across the county in a westerly direction. The central and southeastern portions of the county are drained by branches of Pigeon Creek flowing southward into the Ohio River. Southwestern Gibson County is drained by ditches and small tributaries of the Wabash. Black River rises south of Owensville and flows southwestward into Posey County and thence into the Wabash River.

GEOLOGY

The unconsolidated deposits of Gibson County consist of glacial, lacustrine, and fluviatile sediments. The glacial drift varies from scarcely a trace to many feet in thickness. The river and stream deposits along the rivers and their flood plains are of considerable extent and thickness. The loose sand near the rivers have been shifted by the wind into dunes. The lacustrine deposits occur in the southeastern part of the county. They were deposited during the Illinoian stage of glaciation and were laid down in lakes formed by ponding of

glacial waters. Streams laden with debris flowed out of the driftless area against the great mass of materials at the ice front. Ponding resulted in the formation of extensive lakes. Sediments transported into ~~the~~ ~~lake~~ waters were deposited.

The bedrock formations of Gibson County are chiefly of Post-Allegheny age. In the extreme eastern sections of the county are a few square miles underlain by rocks of the Allegheny series. The strata consist of coal, sandstone, limestone, shales and clays. The bedrock formation are usually easily eroded, so the surface has been leveled off by stream and glacial action.

Many wells have been drilled in this county in the search for oil and gas. Some 290 well logs have been published by Logan (111), which show the various formations

(111) Logan, W.N., The Sub-Surface Strata of Indiana, Publication No. 108. Department of Conservation, State of Indiana, 1931. pp. 131-305.

penetrated by the drill. Many of these records show the water horizons. The following log of the well, known as George Conrad No. 1, Section 10, Township 3 South, Range 9 West, has been selected as typical of the succession of strata and ground water conditions of the county. Well owned by William Bell, surface elevation 438 feet. Published on page 135, of above referred to well records:

Soft yellow clay to	19'
Sand and gravel	32
Dark broken sand	76
Soft, sand,	128 - water
Light soft shale	130
Light soft sand	142
Coal	147
Soft fire clay	159
Light soft sand	203
Dark shale	205
Light sand	220
Dark shale	243
Hard brown sand	247
Coal	252
Gray shale	260
Brown lime	265
Gray sand, gas	330
Dark shale,	340
Brown hard lime	345
Dark shale	353
Gray lime	358
Gray shale	370
Coal, little gas	375
Gray soft shale	398
Dark shale	410
Light sand	425
Light shale	430
Light hard lime	436
[illegible]	[illegible]

Dark shale	439	
Coal	442	
Dark shale	448	
Gray lime	460	
Gray shale	465	
Dark shale	470	
Gray shale	480	
Brown shale	495	
Gray shale	510	
Gray sand	519	
Gray hard lime	523	
Broken gray sand	550	
Gray shale	575	
Brown shale	635	
Soft sand, at 680	753	- water
Good volume of gas	753	
Dark shale	760	
Light hard lime	765	
Gray hard sand	815	
Dark shale	828	
Light hard sand	861	
Gray hard sand	885	
Gray soft sand	920	
Gray hard sand	945	
Dark shale	1028	
Hard cap rock	1032	
Sand, 600,000 cu. ft. gas	1047	
Light fine sand	1050	
Rainbow of oil		
Dark soft sand	1053	- water
Light soft sand	1253	
Dark shale	1255	
Light sand	1257	
Dark shale, soft	1270	
Sandy limestone	1276	
Dark shale	1278	
Hard brown lime	1291	
Dark soft shale	1311	
Gray hard lime	1316	
Dark soft shale	1325	
Light hard sand	1353	
Dark shale	1360	
Dark sandy shale	1367	
Brown hard lime	1402	
Dark shale	1405	
Light limestone	1407	
Shale and red rock	1430	
Light shale, very hard	1433	
Dark shale	1465	
Dark shale, very hard	1468	
Dark shale	1482	
Hard brown lime	1488	
Dark soft shale	1495	
Light hard sand	1505	
Softer sand, little water	1510	- water
Total depth	1510	

Plugged back to gas horizon

Generalized Geologic Section for Gibson County

Quaternary:	
Recent, -- alluvium	0-50'
Pleistocene	0-100'
Pennsylvanian:	1150'
Post-Allegheny	
Allegheny	
Pottsville, -- (Not exposed at surface)	
Mississippian: (Not exposed at surface)	

GROUND WATER

The flood plain deposits of Gibson County are excellent sources of ground water, likewise are the old lake deposits and the sands and gravels of the surficial formations.

The Pennsylvanian sandstones and coals are aquifers, though in many areas mineralized waters occur in the coal beds. Usually soluble compounds of iron are frequent in coal-bearing strata.

Shallow wells, springs, and surface supplies furnish this county with water. Gibson County is fortunate with respect to its proximity to rivers.

Water Supplies of Towns in Gibson County

Princeton. -- (population 7,505) The city of Princeton is supplied with water by the Princeton Water & Lighting Company, a private corporation. The water is secured from the Patoka River and treated by coagulation and filtration processes.

Somerville. -- (population 273) The town of Somerville has no public water supply system.

Francisco. -- (population 728). The town of Francisco has no public water supply system.

Oakland City. -- (population 2,842) The town of Oakland City owns its water system. The supply is obtained from impounding reservoirs.

Haubstadt. -- (population 674) The town of Haubstadt has no public water supply system.

Owensville. -- (population 1,056) The town of Owensville owns its water supply system. The source of water is tubular wells.

Fort Branch. -- (population 1,341) The water supply at Fort Branch is city owned. The source is dug wells.

Hazelton. -- (population 507). The town of Hazelton owns its water system. The supply is obtained from White River.

Patoka. -- (population 634) The town of Patoka has no public water supply system.

GRANT COUNTY

GENERAL FEATURES

Area 423 square miles Population 51,066 (Census of 1930)

Grant County is located about 20 miles northeast of the geographic center of the State. It is the third county west of the Ohio-Indiana State line, and the fourth county south of the Indiana-Michigan State line. Marion is the county seat.

The maximum altitude of the county is 930 feet above sea level and the minimum is 720 feet, thus giving a total maximum relief of 210 feet. The maximum local relief is 65 feet.

"The surface of the county is essentially a plain, dissected by the Mississinewa River and its many tributaries. The only surface relief developed is due to the gradual deepening of the various stream valleys and gullies and the constant lowering of the surface by erosion. Hence, the rougher topography occurs in the vincinity of the stream courses, particularly along the Mississinewa River and along the larger creeks, which have cut their valleys 50 to 100 feet deep through the glacial drift to the river level. The topography near the streams may be described as undulating to hilly, although the crests of the hills are on a level with the plains back from the river. The western, southwestern, eastern, and northeastern parts of the county are comparatively level. The central and northern portions are more broken and are naturally better drained."

Drainage. -- The larger part of the surface drainage of Grant County is controlled by the Mississinewa River. In the south part of the county the drainage is effected by Coon, Deer, Bell, and Prairie creeks, all of which are tributaries of the Mississinewa River. The branches of the Mississinewa which drain the southeastern portion include Three Mile, Lake, Sleepy Hollow, Hog, and Barren creeks. The streams draining the northeastern part include Hummels, Massey, Lugats and Walnut creeks. The southwestern portion of the county is drained by branches of Wild Cat Creek, including Prairie Run, Grassy Fork, Middle Fork, and Polly Walk. The extreme northwestern part of the county is drained by branches of Big Pike Creek, including Brooks, Taylors, Stoney and Pipe creeks. The northeastern portion is drained by a small tributary of the Salamonie River. A small lake in the eastern part of the county is called, "The Lake." It is situated at the head of Lake Creek.

GEOLOGY

The alluvial deposits of Grant County are limited in areal extent. The valley of the Mississinewa is deep and narrow, and none of the tributaries, except Walnut Creek has alluvial bottoms of any extent. The Mississinewa

valley flat is developed to one-fourth to one-half a mile in width at a few places along its course.

Grant County is entirely mantled with glacial drift, which varies from ten to 400 feet in thickness. The greater thickness occurs in preglacial valleys or deeply eroded surfaces.

Dr. A. J. Phinney, in 1883 described the glacial deposits of Grant County as follows:

"Gray clay is the principal deposit over the eastern portion of the county. Its thickness is about 30 feet. Beneath this is the water-bearing bed of sand and gravel; under this lies the blue bowlder clay, so nicely exposed in the bank of the river east of Marion. The bed of sand and gravel is not so constant as the clays. In the western and southern parts, gravel and sand are found in pockets; as wells, sunk only a few feet apart, show, in one, nothing but clay, while the other may strike gravel within a few feet of the surface, and afford an unfailing supply of water. In places, thin beds of gravel are passed through, in digging wells, at a depth of 10 or 15 feet, but water is obtained principally from deeper beds, and is thus freer from impurities. Many of the swamps, bogs and round sink holes or ponds are underlaid with gravel and sand. A pike was being built in Fairmount Township, the gravel for which was taken from a swamp. It was necessary to use a pump to keep the pit free from water. At Jonesboro, the bluffs are composed of sand and gravel; elsewhere observed, they are formed of heavy blue and gray clays. In the southern part of the county, along the river, the gray clays have become yellowish or rusty colored from oxidation or the iron in the limestone, which forms a good portion of the drift, being thoroughly mixed with the clays. South of Marion is a deposit of gravel, below the old bed of the Mississinewa: but this was deposited by the melting glacier, not by the river. It supplies the city and railroads with an abundance of this valuable material.

Bowlders, although common in the county, are not numerous, except in a belt near Jalapa, where are found many large ones. They are principally granites, gneiss, greenstones and quartzites. They were evidently torn from the under surface of the glacier as it passed over the ridge or rock exposed in the bed of the river. Limestone bowlders were once numerous along the river, between Jonesboro and New Cumberland, and were burned for lime."

The above report of the early geologist in Indiana is interesting from several viewpoints. From the standpoint of the hydrologist it is notable that the water-table in Grant County has been lowered to such a remarkable degree. The use of drain tiles, modern agricultural methods, open ditches and gradual absorption of the muck and peat areas by agricultural

interests have aided in the process.

East of the Mississinewa River, and roughly parallel with it, is a well-defined moraine which lies on top of till beds. It is known as the Mississinewa Moraine. The relief of the moraine is about 50 feet which makes it a prominent topographic feature, and is five or six miles in width. In the morainal belt the wells are drilled, and extend to gravel beds 75 to 100 feet below the surface, and the water is secured from the till rather than from the morainal drift.

"Over three-fourths of Grant County is covered by a mantle of till which conceals the rock and varies in thickness in different parts of the county up to 400 feet. This variation is due almost altogether to the irregularities of the underlying rock surface, for the till itself forms a remarkably flat, featureless upland. One of the most prominent features of the rock surface, although there is no trace of its existence in the present surface topography, is a great canyon-like valley, 200 to 300 feet deep, which crosses the northeast corner of the county, Mr. J. A. Bownocker has traced this valley from the Ohio River up the valley of the Little Miami to New Carlisle, Ohio and thence west and northwest into Grant County. Additional well records show it to continue northwest beyond LaFontaine, and it doubtless extends still farther northwest. One well in Miami County about 4 miles north of Peru, is reported to have penetrated over 300 feet of drift without entering rock, and the suggestion is made that the well may be a continuation of this same deep preglacial valley. In the Mississinewa valley below Marion the rock has been exposed by stream cutting, and in the southwest corner of the county, north of Rigdon, it rises within 6 feet of the surface. Thus the thickness of the till is seen to vary within wide limits in different parts of the county."

The bedrock formations of Grant County which lie immediately under the glacial drift consist of strata of Silurian age, Outcrops of the bedrock occur along the courses of the Mississinewa River and Pipe Creek.

Cumings and Shrock (112) have described the outcrops of Silurian strata in Grant County.

112) Cumings, E. R., and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication 75, Dept. of Conservation, State of Indiana., 1928, p. 173.

"The Liston Creek limestone has been quarried at a number of places in this county for building and foundation stone and for road material. In the north part of Marion, along State Road 15, in the S. W, ¼ of Sec. 31, T. 25 N., R. 8 E., are two small abandoned quarries, one on each side of the road, from which the slabby Liston Creek limestone has been quarried. Both openings are now full of water. The Mississinewa shale has also been

quarried rather extensively about Marion for building stone (Phinney, 1884, 144-149). Three and one-fourth miles southeast of Swoetser, in the N.W.¼ of Sec. 16, T. 24 N., R. 7 E., along Pipe Creek, a small quarry in the Liston Creek limestone has recently been operated. The stone was crushed for local road purposes. One mile southeast of Mier, in the S. ½ of Sec. 35, T. 23 N., R. 6 E., several small quarries were once operated. These openings were made in the inclined strata of a reef. Limestone also outcrops in the bed of Pipe Creek nearby. The stone was crushed and used locally for road construction. A small quarry was once worked about a mile northeast of Rigdon. The crushed stone, which is of Liston Creek age, was used for local road repair."

Generalized Geologic Section For Grant County

Quaternary:
Recent, -- chiefly alluvial materals . . 0-40'
Pleistocene, -- glacial drift . . . . . .0-425'
Silurian:
Liston Creek, -- limestone . . . . . 15-20'
Mississinewa, -- shale (Exposed along Mississinewa River). . . . . 20-30'
Ordovician: (Not exposed in county) . . . . .

GROUND WATER

Ground water may be secured almost anywhere in Grant County in the valley alluvium and it is not necessary to sink deep wells where the alluvium is present. The alluvial deposits all occur along the bottoms of the larger valley, more especially that of the Mississinewa River, The thickness of the alluvium varies. In places the Mississinewa River flows over bedrock and in such places the alluvium is quite thin, In the first or lower portion of the valley flats, the water table is slightly above the water level of the river, though, in the higher terraces the water table is farther from the surface.

In the glacial drift which covers the county, ground water can usually be obtained, however, in certain areas the till is composed chiefly of clay and wells are not large producers. Where the till is thick, deep wells invariably encounter good supplies of water in gravel and where the till is thin the wells are usually drilled into the bedrock.

The bedrock formation immediately underlying the drift is the Liston Creek limestone. The water available to wells drilled into the limestone is from joints and bedding planes The Liston Creek limestone has become an important source of water in Grant County and in areas topographically low, many of the wells flow.

Grant County was exploited for oil and gas following their discovery in this general area in 1886. Many of the

resent good wells in the county are the results of that drill-
ng campaign. It was always necessary to case-off the water
n the upper formations. When the well failed or for any
eason was abandoned, the owners usually "pulled" the casing
or use in another well. In many cases, unless the salt
ater which invariably was present from the oil producing
tratum, was plugged off, the upper horizons became polluted.

Many flowing wells in the county were of the artesian
ype due to the heavy gas pressure which lifted the water
o the surface, however, other artesian wells were of the
ormal type, and not due to gas pressure.

Capps in Water-Supply Paper Number 254 has described
ells in the limestone area which were in "sympathy." At
arion, a flowing well at Matter Park and the wells of the
arion Paper Company were in sympathy. When the wells of
he paper company were drawn on heavily during the week, the
atter Park well ceased to flow, however, on Sunday when the
aper mill was idle the Matter Park well resumed its strong
low, This illustrates the underground connection between
ells drilled into limestone.

Water Supplies of Towns in Grant County

Marion. -- (population 24,496) The city of Marion owns
ts water plant which obtains the city supply from 20 wells
hich vary in depth. The wells produce water from the lime-
tone found at 139 feet. The limestone is exposed in the river
ed at Marion and in some parts of the town it is 200 feet
elow the surface, so it depends on the location of the well
s to the depth at which bedrock will occur. In recent
ears the city of Marion has had wells drilled into the
lacial drift which have given satisfactory service.

Fairmount. --(population 2,056) The town of Fairmount
wns and operates the waterworks which supplies the city.
our wells drilled into the limestone, which here lies 16 feet
elow the surface supply the needs of the town with approxi-
ately 220,000 gallons per day. The wells are 4, 8, and 12
nches in diameter. The 12-inch well was drilled in 1922,
he others in 1893. Some private wells are in use in Fairmount
nd average 40 feet in depth.

Fowlerton. -- (population 204) The town of Fowlerton
s no public water supply system.

Matthews. -- (population 513) The town of Matthews has
public water supply system.

Upland . -- (population 906) The town of Upland owns its
ter system. Two wells, six inches in diameter drilled in
97 to a depth of 185 feet into bedrock supply the town with
ter. The water is reported to have an iron taste and is
ite hard. Water stands about 90 feet in the wells.

Gas City. -- (population 3,087) The city of Gas City
ns its water system..Five wells drilled into the under-

lying limestone produce the water. The limestone occurs at 105 feet and the water horizon is found at 128 feet.

Jonesboro. -- (population 1,496) The town of Jonesboro owns a municipal water plant, however, the dug wells are not in use. The supply at present is obtained from Gas City.

Swayzee. --(population 604) The town of Swayzee has no public water supply system.

Van Buren. -- (population 766) The town of Van Buren owns its water system. The supply is obtained from tubular wells. Limestone was penetrated at 100 feet. The source of water is the drift water which percolates downward into the limestone.

Typical Wells in Grant County

Location	Depth	Quality	Quantity	Formation	Construction
T24N-R8E Sec. 7	---	---	---	Limestone	---
T24N-R8E Sec. 33	35-300'	Hard	Good	Gravel & Limestone	Driven & Dri
T23N-R8E Sec. 29	20-90	"	"	Gravel & Limestone	"
T24N-R8E Sec. 33	15-60	"	"	Gravel	"
T23N-R9E Sec. 3	15-100	"	"	Gravel & Limestone	"
T25N-R9E Sec. 15	60-140	"	"	Gravel & Limestone	"
T24N-R8E Sec. 21	15-500	"	"	Gravel & Limestone	"
T22N-R9E Sec. 4	15-60	"	"	Gravel	"
T24N-R6E Sec. 26	18-100	"	"	Gravel & Limestone	"
T24N-R9E Sec. 9	20-120	"	"	Gravel	"
T23N-R9E Sec. 35	25-120	"	"	Gravel & Limestone	"
Fowlerton	15-200	"	"	Gravel & Limestone	"
T23N-R7E Sec. 21	20-40	"	"	Limestone	"
T25N-R8E Sec. 21	10-200	"	"	Gravel -- Limestone at 400'	"
T24N-R6E Sec. 24	10-120	"	"	Gravel & Limestone	"
T24N-R9E Sec. 12	15-300	"	"	Gravel & Limestone	"
T25N-R7E Sec. 9	40-60	"	"	Limestone	"
T25N-R9E Sec. 19	10-150	"	"	Gravel & Limestone	"

cation	Depth	Quality	Quantity	Formation	Construction
25-R7E					
Sec. 36	15-104	Hard	Good	Gravel & limestone	Driven & Drilled
23N-R6E					
Sec. 3	20-35	"	"	Gravel -- Limestone at 98'	" "
23N-R6E					
Sec. 23	20-125	"	"	Gravel & limestone	" "
24N-R8E					
Sec. 12	90-100	"	"	Gravel -- Limestone at 185'	" "
adley	15-45	"	"	Gravel & limestone	" "
22N-R6E					
Sec.12	20-50	"	"	Gravel & limestone	" "
24N-R6E					
Sec. 28	10-105	"	"	Gravel & limestone	" "
24N-R6E					
Sec. 30	15-100	"	"	Gravel & limestone	" "
24N-R7E					
Sec. 22	10-50	"	"	Gravel	" "
Marion				Wells in limestone	
as City	35			Gravel	City Supply Co.
	300			Limestone	
airmount	20-90			Limestone	City wells
	20-40				Private wells
onesboro	25			Gravel	Dug Well
	15-60			Gravel	Private wells
pland	15-110			Gravel	
	190			Limestone	
an Buren	140			Limestone	
	60-80			Gravel	
ational					
ilitary	15-87			Gravel	
ome	340-500			Limestone	
atthews	15-60			Gravel	
wayzee	18			Gravel	
	100			Limestone	
rcana	20-120			Gravel	
arrville	25			Gravel	
	120			Limestone	
owlerton	15			Gravel	
	200			Limestone	
eckleman	20-40			Limestone	
assfield	10-200			Gravel	
	400			Limestone	
erbst	10-20			Gravel	
	120			Limestone	
adden	15-100			Gravel	
	300			Limestone	
alapa	40-60			Limestone	
andess	10-100			Gravel	
	150			Limestone	
ier	15-25			Gravel	
	104			Limestone	
ormal	20-30			Gravel	
	98			Limestone	

Location	Depth	Quality	Quantity	Formation	Construction
Point Isabel	120-30			Gravel	
	125			Limestone	
Puckett	90-100			Gravel	
"	185			Rock	
Radley	15-20			Gravel	
"	35-45			Limestone	
Rigdon	20-40			Gravel	
"	45-50			Limestone	
Roseburg	10-50			Gravel	
"	60-105			Limestone	
Sims	10-50			Gravel	
"	60-100			Limestone	
Sweetser	15-40			Gravel	
T25N-R8E					
Sec. 7	140	Hard	Good	Gravel	Drilled
Sec. 17	128	"	"	"	"
Sec. 23	150	"	"	Limestone	"
Sec. 23	20	"	"	Sand & gravel	Dug
Sec. 28	104	"	"	Gravel	Drilled
Sec. 30	80	"	"	Sand	"
T23N-R9E					
Sec. 3	254	"	"	Limestone	"
Sec. 17	60	"	Medium	Gravel	"
Sec. 36	62	"	Good	"	"
T23N-R8E					
Sec. 25	185	"	"	Limestone	"
Sec. 27	105-380	"	"	"	"
Sec. 29	85	"	"	Gravel	"
T23N-R7E					
Sec. 12	60	"	"	Limestone	"
Sec. 21	37	"	"	"	"
Sec. 25	120	"	"	Gravel	"
T24N-R9E					
Sec. 3	70	"	"	"	"
Sec. 8	60	"	"	"	"
Sec. 11	85	"	"	"	"
Sec. 15	78	"	"	"	"
Sec. 27	85	"	"	"	"
T24N-R8E					
Sec. 11	24'	"	"	"	Dug
T25N-R7E					
Sec. 11	60	"	"	"	Drilled
Sec. 12	30	Medium	"	"	"
Sec. 15	120	Hard	"	Lime	"
Sec. 26	16	Medium	"	Gravel	Dug
Sec. 26	78	Medium	"	"	Drilled
Sec. 36	95	Hard	"	Lime	"
T25N-R9E					
Sec. 1	70	"	"	Gravel	"
Sec. 22	50	Medium	"	"	"
T25N-R6E					
Sec. 21	90	Hard	"	Lime	"
Sec. 22	144	"	"	Gravel	"
Sec. 25	120	"	"	Lime	"
Sec. 35	100	"	"	"	"

ocation	Depth	Quality	Quantity	Formation	Construction
23N-R6E					
Sec. 11	103	Medium	Good	Gravel	Driven
Sec. 23	70	Hard	"	Limestone	Drilled
Sec. 24	64	"	"	"	"
24N-R6E					
Sec. 14	50	"	"	"	"
Sec. 26	80	"	"	"	"
Sec. 35	60	Soft	"	"	"
24N-R7E					
Sec. 13	50	Hard	"	Gravel	"
Sec. 15	35	"	"	Limestone	"
Sec. 21	148	"	"	"	"
Sec. 24	87	"	"	"	"

CHEMICAL ANALYSES OF GRANT COUNTY WATERS (113)
(Parts per million)

Location	Geological conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
Arcana	Limestone		0.40		90	45			0.0	263	642	8	.30	0.001	0	730
Fairmount	Limestone		.0		124	41				352	290	68	.05	.0	2	736
Fowlerton	Gravel		1.2		61	28				322	34	2	0	.05	4	448
Gas City	Gravel		.08		38	30				305	84	6	.20	.004	0	558
Hanfield	Gravel		.4		615	370				428	392	7,640	0	.001	33	17,604
Herbst	Sand		.3		157	37				286	248	77	77	0	4	662
Jalapa	Gravel		.01		94	27				268	154	40	3.0	0	0	576
Jonesboro	Gravel		.80		40	37				311	128	5	0	0	2	464
Landess	Gravel		.20		95	41				296	82	7	0	0	4	542
Marion			12	3.2	114	38	1.80	.32	217		47	4.1				
Marion			.12		72	34		8.7	191		42	10				364
Swayzee	Limestone		.4		124	38				326	373	8		.01	2	448
Marion	Gravel		Tr.		123	31					26	12				432
Point Isabel	Limestone		0.6		59	30				306	138	3			2	492
Marion	Gravel		Tr.		169	49					127	37				830
Matthews	Sand		1.0		86	31				362	45	5			6	504
Marion	Limestone		Tr.		107	38					29	71				535
Marion	Limestone		1.4		70	29				320	35	8			9	418
Marion	Limestone		.97		69	35		28		322	36	24				371
Matter Park	Limestone		1.5		79	43		55		321	158	28				569
Marion	Gravel		1.0		102	40				390	166	6			4	548
Sweetzers	Limestone		.1		71	32				335	44	8			0	458
Van Buren	Limestone		2.0		126	29				335	180	5			9	742
Van Buren	Gravel		2.4		111	30				349	167	6			9	622

(113) From Water-Supply Paper 254, page 127.

G R E E N E C O U N T Y

GENERAL FEATURES

Area 543 square miles Population 31,481 (Census of 1930)

Greene County is located in the southwestern part of the State. It is the second county east of the Illinois-Indiana State line, and the fourth county north of the Indiana-Kentucky State line.

The maximum altitude in Greene County is 925 feet above sea level and the minimum is 470 feet above sea level, thus giving a total maximum relief of 455 feet. The maximum local relief is 500 feet. The eastern one-third of Greene County is within the unglaciated area of southern Indiana. This part of the county is very hilly. It is a part of the Crawford Upland. The western portion of the county is in the Wabash Lowland and characterized by aggraded valleys which afford little relief.

Drainage. --The West Fork of White River flows through the central portion of Greene County. Most of the drainage of the county goes into White River. The principal tributary is Eel River which also enters the county from the north and joins White River at Worthington. The northeastern part of the county is drained by Richland Creek and its chief eastern tributary, Beech Creek. The southeastern portion is drained by another branch of Richland Creek, Plummers Creek and by Doans Creek, the latter a branch of West Fork of White River. A part of southeastern Greene County drainage enters the East Fork of White River by way of Indian Creek. Two small tributaries of Eel River drain the northwestern part of the county. The southeastern part is drained by Black Creek, a branch of the West Fork of White River.

GEOLOGY

The unconsolidated deposits of Greene County consist of glacial drift, valley train deposits and alluvial deposits of the flood plain type along the major streams. The glacial drift in western Greene County is from 10 to 20 feet in thickness. In certain areas the drift has been entirely removed exposing bedrock. Also preglacial channels have been filled so that greater thicknesses of drift accumulated. The valleys of the West Fork of White River, Eel River, Richland Creek, and other streams in the glaciated area have wide flood plains and thick deposits of alluvium.

The bedrock formations of Greene County are composed of strata of Mississippian and Pennsylvanian age. Outcrops of shales, limestones, and sandstones belonging to the Chester series of the Mississippian are present in the eastern part of

the county. The basal sandstone of the Pennsylvanian (Mansfield) rests on the Chester in this area. The strata of the Pennsylvanian system are subdivided into the Pottsville and Allegheny series, from east to west in the order of their outcrop.

Generalized Geologic Section for Greene County

Quaternary:	
Recent, -- chiefly alluvium and residual materials	0- 30'
Pleistocene, -- glacial drift, outwash deposits	0- 75'
Pennsylvanian:	600'
Allegheny, --	
Pottsville, --	
Mississippian:	
Chester, --	225'
Ste. Genevieve, --	100'
St. Louis	100'

GROUND WATER

The alluvial materials adjacent to the major streams are excellent sources of water. The city of Bloomfield obtains a city supply from wells drilled into the gravels and sands in the flood plain of the West Fork of White River. The glacial drift is a source of water, where the drift is sufficiently thick. Th valley trains and outwash materials deposited by waters from the melting ice are also sources of water.

Many springs occur in Greene County, especially in the eastern portion of the area which is unglaciated and has Chester formations outcropping.

Shallow wells usually obtain water supplies adequate for farm and home use. Streams and ponds furnish stock water. Cisterns are utilized for home use in areas where ground water is difficult to obtain.

Typical Wells of Greene County

Location	Depth	Quality	Quantity	Formation	Construct
T6N-R7W					
Sec. 3	75'	Hard	Good	Rock	Drilled
Sec. 11	82'	"	"	"	"
Sec. 14	25'	"	Poor	"	Dug"
Sec. 22	40'	"	Good	Gravel	Driven
Sec. 26	80'	"	"	Rock	Drilled (Marc
T7N-R7W					
Sec. 4	160'	"	"	"	"
Sec. 27	450'	Sulphur Water	"	"	"

Location	Depth	Quality	Quantity	Formation	Construction
T8N-R7W					
Sec. 2	40- 62'	Hard	Good	Gravel & Rock	Drilled
Sec. 16	22- 40'	"	"	Gravel & Clay	Dug
Sec. 28	16'	"	"	Gravel & Clay	Dug
T8N-R6W					
Sec. 2	100-202'	"	"	Rock	Drilled
Sec. 6	25'	"	"	"	"
Sec. 26	40'	"	"	Clay & Kaolin	Dug
T7N-R6W					
Sec. 1	30- 60'	"	"	Gravel	Drilled
Sec. 11	20'	"	"	Clay	Dug
Sec. 14	75-125'	"	"	Rock	Drilled (Switz City)
T8N-R5W					
Sec. 22	30'	"	"	Gravel	Drilled
Sec. 23	40'	"	"	Sand & Gravel	"
T8N-R4W					
Sec. 20	10-100'	"	"	Gravel	Driven & Drilled
Sec. 22	38'	"	Poor	Limestone	Dug
Sec. 24	26'	"	Good	Rock	Dug
T7N-R5W					
Sec. 10	25- 30'	"	Medium	"	Dug
Sec. 15	40'	"	"	Sandstone	Drilled & Dug
Sec. 25	20'	"	Good	"	Drilled & Dug
T7N-R4W					
Sec. 28	50'	"	"	"	Drilled
T8N-R3W					
Sec. 14	25- 30'	"	"	Rock	Dug (Hendricksville)
Sec. 23	30'	"	"	"	Springs & Dug
Sec. 22	25- 30'	"	"	Limestone & Sandstone	Drilled & Dug (Solisbury)
T7N-R3W					
Sec. 12	40'	"	"	Sandstone	Drilled
Sec. 22	22'	"	"	Limestone	Dug
Sec. 27	85'	"	Poor	Shale	Drilled (Cincinnati)
Sec. 30	56- 74-45'	"	Good	Sandstone	Drilled
Sec. 35	40- 50'	"	"	"	Drilled (Hobbieville)
T6N-R3W					
Sec. 4	50'	"	"	Sandstone	Drilled
Sec. 8	20- 30'	"	"	Gravel	Drilled
Sec. 21	17'	"	"	"	Dug (Dresden)
Sec. 27	20- 60'	"	Poor	Limestone	Dug & Drilled
T6N-R4W					
Sec. 4	21'	"	Good	Gravel	Dug

Location	Depth	Quality	Quantity	Formation	Construction
T6N-R4W					
Sec. 6	40'	Hard	Good	------	Dug
Sec. 25	26'	"	"	Soapstone	"
Sec. 28	15- 20'	"	"	Clay	" (Doans)
T6N-R5W					
Sec. 10	25'	"	"	Sand	"
Sec. 12	40'	"	"	Sand & Gravel	" (Mineral)
Sec. 15	42'	"	Medium	Sandstone	"
Sec. 30	35'	"	Poor	Gravel & Sand	"
Sec. 36	40- 60'	"	Good	Gravel	" (Scotland)
T6N-R6W					
Sec. 8	20'	"	"	Sand & Gravel	Driven
Sec. 14	150'	"	"	Sandstone	Drilled
Sec. 21	20- 30'	"	"	Sand & Gravel	Driven
Sec. 25	25'	"	Poor	Sand & Gravel	Dug (Newberry)

Water Supplies of Towns in Greene County.

Bloomfield. -- (population 2,298) The town of Bloomfield is supplied water by the Interstate Public Service Company, a private corporation. The water is obtained from two wells drilled into the alluvial sediments of White River flood plain. The wells are 12 inches in diameter. They were drilled in 1926 and 1928.

Jasonville. -- (population 3,536) The city of Jasonville has been furnished water from a tubular well by a private corporation, the Jasonville Water Company. Bedrock is penetrated at 25 feet. The water-bearing stratum is a blue limestone and blue shale according to reports. The well is 10 inches in diameter, drilled in 1913.

Linton. -- (population 5,085) The city of Linton owns its water system. The supply is obtained from eight wells drilled into gravels of glacial drift. The depth to bedrock is 74 feet. Water stands at 34 feet in the wells. The wells are 12 inches in diameter and were drilled in August, 1928. Seasonal variatic in hydrostatic pressure have been noted.

Worthington. -- (population 1,687) The town of Worthingtor is furnished water by the Interstate Public Service Company, a private corporation. Five wells produce water from the valley alluvium. No bedrock is penetrated in the wells. A few flowing artesian wells are reported in the southwestern portion of Worthington. Many private wells are used and the water level is only 18 feet from the surface. The location of the town near the junction of two major streams assures a permanent water sup-

Newberry. -- (population 366) The town of Newberry has no public water supply system.

Switz City. -- (population 450) The town of Switz City has no public water supply system.

Lyons. -- (population 806) The town of Lyons has no public water supply system.

HAMILTON COUNTY

GENERAL FEATURES

a 399 square miles : Population 23,444 (Census of 1930)

Hamilton County is located in central Indiana, just north the geographic center of the State. The county is approximately quare, 20 miles each way.

The maximum altitude of Hamilton County is 950 feet above level, and the minimum is 725 feet above sea level, thus giving otal maximum relief of 225 feet. The maximum local relief is 35 t.

The surface of the county is composed of ground moraine the most part, which has been dissected by streams. The till in is fairly level except it is quite hilly in the vicinity of eams, or where moraines exist in the western edge of the county. road belt of moraines in the western half of the county is quite and in places merges into the ground moraine, or at least can- be distinguished from it. The surface configuration of the en e county has been determined by the glacial deposits and by the sent streams. The bedrock is so deeply buried that its irregu- surface has no effect upon the present topography.

Drainage. -- The entire drainage of Hamilton County is in- ded in the West Fork of White River basin. This river enters n Madison County on the east at a point about ten miles south of northeastern corner of Hamilton County and flows in a south - twardly direction through the county to enter Marion County about miles from its eastern boundary. The northeastern part of the nty is drained by Duck Creek; and its two branches, Long and , and Sugar Run. The central part is drained by East Creek n its tributaries, Hinkle, Lick, West, Cicero, and Weasel Creeks. southeastern portion is drained by Fall Creek and its tributar- , Crosby and Sandy. The extreme northwestern part of the drained by Finley, Eagle, Lick, West, and Long Creeks. All of streams are part of the West Fork of White River drainage system.

GEOLOGY

The unconsolidated surficial materials of Hamilton County ist of glacial and alluvial deposits. The alluvial materials along the main streams and White River. At the present time e River has a valley flat of considerable width and terrace de- ts which have been developed above the present flood plain. glacial deposits consist of ground moraine and terminal moraine.

The moraines, all located in the western portion of the county, are of low relief. It has been estimated that three-fourths of the surface of Hamilton County consists of till plain. The drift will average about 100 feet in thickness. Most of the stream valleys are underlain by till.

The bedrock formations of the county are of Silurian and Devonian age. The Silurian strata underlie the drift in the northeastern half of the county. The Devonian strata underlie the drift in the remainder of the county. Outcrops of bedrock occur in Section 36, T. 20 N., Range 5 East; in Sections 9, 16, 26 and 31 in Township 19 N, Range 5E; in Section 29, Township 19 N, Range 6 east; in Section 32, Township 18 north, Range 6 east; and in Section 6, Township 17 north, Range 6 east. With the exception of the outcrops named, the surface of the bedrock is covered. In many areas the bedrock surface is irregular, which accounts for the varying thickness of the drift.

Generalized Geologic Section for Hamilton County

Quaternary:	
Recent, -- chiefly alluvium.	0- 40'
Pleistocene, -- glacial deposits	0-352'
Devonian:	
New Albany, -- shale (underlies drift in southwestern corner of the county) . . .	Thin
Devonian limestone, --	40'
Silurian:	
Liston Creek, -- limestone	Thickness unknown
Ordovician: (Not exposed)	

GROUND WATER

Ground water may be obtained from several geological horizons in Hamilton County. The alluvial flats along the rivers and streams, the glacial drift, and the bedrock of Silurian age are aquifers. As a result of the wide distribution of till at the surface and its great thickness more wells in this county draw

their water from till than from all other sources. The clay layers of the till give up their contained water very slowly. As a result, where greater quantities of water are demanded, the wells are drilled to greater depths. If it is possible to intercept a gravel horizon in the till, water flows more freely. If the gravel lense is large an abundance of water is secured.

The drift yields hard waters that differ in mineral content. Capps in Water-Supply Paper No. 254 has given analyses of water from ten different locations in the county. The total solids vary from 350 to 1,284 parts per million. It is interesting to observe that the well showing 1,284 parts per million was an open well, only 17 feet in depth. The well in which the water showed 350 parts per million was 163 feet deep, producing from gravel. The analyses of waters coming from limestone showed no essential variation from those waters from the drift.

Silurian strata outcrop at a few points in the valley of White River and in the valley of Fall Creek. Many wells penetrate the Liston Creek limestone in order to obtain water from the joints and bedding planes. The drift accumulates the supplies which penetrate the cavities and open spaces of the limestone. The Devonian limestone underlies the western half of the county with the exception of the very southwestern corner. The Devonian limestone also contains water which is yielded to wells. The shale is not an aquifer and will not furnish supplies.

Water Supplies of Towns in Hamilton County.

Sheridan. -- (population 1,763). The town of Sheridan is supplied water by wells privately owned. The wells are drilled through the drift into the Devonian limestone. One well is 196 feet in depth, the other is 200 feet. Water stands at 45 feet which is the general level of water in wells in the community.

Carmel. -- (population 682). The town of Carmel owns its water supply system. The water is obtained from a tubular well.

Atlanta. -- (population 551). The town of Atlanta has no public water supply system.

Westfield. -- (population 688). The town of Westfield owns one tubular well from which the public supply is obtained.

Noblesville. -- (population 4,811). The city of Noblesville is furnished water by the Noblesville Water and Light Company, a private corporation. The supply is obtained from sixteen wells. Some of the wells produce from gravels and others are drilled into the Silurian limestone. Some of the wells penetrated bedrock at a depth of 80 feet.

Arcadia. -- (population 912). The town of Arcadia owns one tubular well from which the public water supply is obtained.

Fishers Station. -- (population 138). The town of Fisher Station has no public water supply system.

Cicero. -- (population). The town of Cicero owns its water supply system. The water is obtained from one well drilled into the Silurian limestone which was penetrated at 135 feet. Water stands at 25 feet in the well and at the same depth in the glacial drift of other privately owned wells in the vicinity.

Typical Wells of Hamilton County

Location	Depth	Quality	Quantity	Formation	Construct
T19N-R5E Sec. 31	35-175'	Hard	Good	Gravel & Limestone	Driven &
T20N-R3E Sec. 32	20-150'	"	"	Gravel-Limestone at 200'	"
T20N-R4E Sec. 36	10-160'	"	"	Gravel-Limestone at 165'	"
T20N-R4E Sec. 14	10-205'	"	"	Gravel & Limestone	"
Atlanta	10-300'	"	"	Gravel & Limestone	"
T20N-R6E Sec. 8	10-125'	"	"	Gravel & Limestone	"
T20N-R3E Sec. 36	20-140'	"	"	Gravel	"
T20N-R3E Sec. 22	20- 75'	"	"	"	"
T18N-R3E Sec. 25	30-120'	"	"	"	"
T18N-R5E Sec. 3	10- 75'	"	"	Gravel & Limestone	"
T19N-R4E Sec. 5	10-142'	"	"	Gravel	"
T19N-R5E Sec. 36	15- 90'	"	"	Gravel & Limestone	"
T19N-R3E Sec. 33	15-200'	"	"	Gravel-Limestone at 200'	"
T18N-R4E Sec. 36	25-125'	"	"	Gravel & Limestone	"
T19N-R3E Sec. 2	10-125'	"	"	Gravel-Limestone at 240'	"
T19N-R3E Sec. 31	20-100'	"	"	Gravel	"
T18N-R4E Sec. 7	10-110'	"	"	"	"
T20N-R5E Sec. 10	10-200'	"	"	Gravel-Limestone at 280'	"

Typical Wells of Hamilton County

Location	Depth	Quality	Quantity	Formation	Construction
T19N-R5E Sec. 3	25-112'	Hard	Good	Gravel & Limestone	Driven & Drilled
T19N-R4E Sec. 31	20-185'	"	"	Gravel-Limestone at 200'	" "
Noblesville				Drilled wells 33' to 73' gravel. Limestone 55' to 175'	
Sheridan	135-150'			Gravel	Rock 200'
	20- 30'			Private wells	
Cicero	10- 40'	(shallow wells in		Gravel--Deeper 160--Rock 165'	
Arcadia	10-125'			Gravel	
	130-205'			Limestone	
Atlanta	10-130'			Gravel	
	220-300'			Limestone	
Aroma	10- 50'			Gravel	
	105-125'			Limestone	
Baker's Corners	20- 40'			Gravel	
Boxley	20- 75'			Gravel	
Carmel	3 -100'			Gravel	
	100-120'			Limestone	
Clarksville	10- 20'			Gravel	
	20- 75'			Limestone	
Doming	10-142'			Gravel	
Durbin	15- 30'			Gravel	
	70- 90'			Limestone	
Eagletown	15-200'			Gravel	
	200'			Limestone	
Fisher's	25-100'			Gravel--	
	100-125'			Limestone	
Horton	10-125'			Gravel--Rock 240'	
Jolietville	20-100'			Gravel	
New Britton	10-110'			Gravel	
Omega	10-200'			Gravel--Rock 280'	
Strawtown	25- 50'			Gravel	
	50-112'			Limestown	
Westfield	20-185'			Gravel--Rock 200'	

MINERAL ANALYSES OF WATERS IN HAMILTON COUNTY(114)9
(Parts per million)

Location	Geological Conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	Color	Total solids
Arcadia	Gravel		.12		80	24			272	15	.6	.50		9	350
Arcadia	Limestone		.4		80	25			280	20	4	.25	.000	19	384
Atlanta	Gravel		.40		81	65			232	97	60	.30			370
Cicero					81	29	17	194		5.9	22				
Cicero	Gravel		.80		170	25			344	20	12	.001	1.2	23	362
Cicero	Gravel				256	71			416	665	140	.05		22	1284
5 mi. W. of Cicero	Limestone		1.4		79	27			260	15	18	.20		19	442
Noblesville	Gravel	20	2.0		84	31	19		352	32	16	2.8			376
Noblesville	Limestone	21	3.0		82	30	18		372	22	17	.04			375
Noblesville					112	35	17	188		70	25	39			
Sheridan	Gravel	21	1.8		61	27	47	Tr.	431	5.6	1.5	4.			396
Strawton	Limestone		3.0		94	10			278	1	7	1.10		13	438

(114) From Water-Supply Paper No. 254, p. 137.

HANCOCK COUNTY

GENERAL FEATURES

Area 307 square miles Population 16,605 (Census of 1930)

Hancock County is located slightly east of the central part of the State. It is the first county east of Marion County in which Indianapolis is located. Greenfield is the county seat.

The maximum altitude of Hancock County is 1,025 feet above sea level and the minimum is 790 feet, thus giving a total maximum relief of 235 feet. The maximum local relief is 70 feet. The county for the most part is an upland area which is level to gently rolling. The streams have low gradients and the rougher topography occurs near the streams. The interstream areas have very low relief and in many instances it has been necessary to resort to artificial methods for adequate drainage. The entire surface of the county is mantled with glacial debris. The north and northwest portions are a till plain, however, a broad morainal belt extends northeast-southwest across the county from these two corners. Also there is a belt of moraines in the southeastern part of the county, with an area of till plain between the two mentioned morainal belts. The extreme southeastern corner of the county is within the valley of the Big Blue River and has been modified by that stream.

Drainage. -- All of the drainage of Hancock County is controlled by the East and West Forks of White River. The principal stream in the county is Sugar Creek which heads in the northeastern part of the county and flows southwestward across the county.

Little Sugar Creek rises in the eastern part of the county and flows southward to enter Sugar Creek beyond the county line. The northwestern corner of the county is drained by a branch of Fall Creek; the Flat Fork of Fall Creek, which flows in a northwesterly direction out of the county. East of Little Sugar is the Willow Branch of Brandywine Creek. This stream heads in the northeastern part of the county and flows southward beyond the county.

The drainage of the western portion of the county is accomplished by Indian Creek, Buck Creek, and Hoe Creek, all branches of the West Fork of White River and named in order from north to south.

GEOLOGY

The unconsolidated deposits of Hancock County consist of till plains and morainal drift, also alluvial deposits in the valley flats of the major streams. The bottoms

of Big Blue River, Brandywine, and Sugar Creeks contain important deposits of alluvium. The valley of the Big Blue River served as a channel for melting waters of the ice during glacial times and consequently the present valley is much greater than the present Big Blue would have developed. This accounts for the extensive alluvial deposits along this stream. The alluvium ranges from 20 to 40 feet in thickness. The terrace development along Big Blue is also a feature formed during the melting of ice and the accompanying aggradation.

Two belts of moraines trend northeast-southwest across the county, and these areas consist of low rolling hills dotted with bowlders of foreign origin.

The bedrock formations of the county consist of strata of Silurian and Devonian age. The Silurian formations occupy the northeastern one-half of the county. In the southwestern one-half of the county Devonian strata underlie the drift. The drift attains a thickness of as much as 250 feet. No outcrops of bedrock occur in the county. The geologic succession and distribution of strata have been determined from well records and the known distribution of strata in adjacent counties. The Silurian and Devonian formations are limestones. Details of the stratigraphy are unknown as no outcrops occur.

Generalized Geologic Section for Hancock County

Quaternary:	
Recent, -- alluvium and residual materials ...	0-40'
Pleistocene, -- glacial deposits	75-300'
Devonian:	
Devonian, -- limestones (Do not outcrop) . . .	40'
Silurian:	
(No outcrops, but determined from well logs and distribution in adjacent counties)	140' ?
Ordovician: (No outcrops)	600' ?

GROUND WATER

Most of the water used for domestic purposes in Hancock County has its source in the ground. It may be obtained from a number of geologic horizons. The alluvial deposits in the valley flats of the major streams contain an abundance of water. The till which covers the county is the source of most of the water. The clayey till will permit a slow seep of water into the wells. Many wells are drilled to greater depths in order to penetrate a lense of gravel or sand. In most cases wells which furnish adequate supplies can be obtained without drilling into bedrock. The moraines of this county are not high as are those in northern Indiana. Ground water conditions in the morainal belts are very similar to those of the till. Frequently it is necessary to drill to greater depths in order to secure water. Many dug wells are in use in the county.

The bedrock formations which underlie the drift in this county are chiefly limestones. The water occurs in the weathered upper surfaces of the limestones, or in fractures, joints, or bedding planes. Both Silurian and Devonian limestones are aquifers. It is not necessary to penetrate the bedrock to great depths in order to obtain adequate potable supplies. A few feet into bedrock will give a better well than will deep penetration. The deeper horizons are likely to contain mineral waters, unfit for use.

Water Supplies of Towns in Hancock County

Shirley. -- (population 761) The town of Shirley owns its water supply system. Tubular wells drilled into the Silurian limestone furnish the water. The limestone is penetrated at 300 feet and hydrostatic pressure raises the water level to within 30 feet of the surface. Shirley is in part in Henry County, being divided as follows: Hancock County 620, Henry County 141.

Wilkinson. -- (population 316) The town of Wilkinson has no public water supply system.

Greenfield. -- (population 4,188) The city of Greenfield owns and operates its public water supply system. Two wells, 12 inches in diameter are estinated to produce 1,500,000 gallons per day. It is 148 feet to bedrock, which is Devonian limestone. The water horizon consists of 40 feet of gravel above bedrock. Hydrostatic pressure raises the water to the surface. Greenfield has excellent ground water conditions and can obtain adequate supplies either from drift or bedrock. Mineral analyses of the city supply as given by Capps in Water-Supply Paper No. 254 indicate 326 parts per million of total solids.

Fortville. --(population 1,289) The town of Fortville owns its public water supply system. The water is obtained from two wells drilled into the gravels. One well is 104 feet, the other is 119 feet, both are eight inch wells. At Fortville two good gravel horizons are reported, the first at 15 feet, the second at 80 feet. Bedrock is penetrated at 165 feet with excellent water supplies to be obtained. The second gravel at about 80 feet is the main water producing stratum in this locality.

New Palestine. -- (population 456) The town of New Palestine is supplied water from tubular wells, privately owned.

Spring Lake Park. -- (population 69) The town of Spring Lake Park has no public water supply system.

Typical Wells in Hancock County

Location	Depth	Quality	Quantity	Formation	Construction
T15N-R7E Sec. 5	20-220'	Hard	Abundant	Gravel & Limestone	Dug-Driven-Drilled
T15N-R6E Sec. 27	15-125	"	"	Gravel-Lime stone at 285'	Dug, Driven Drilled
T17N-R6E Sec. 3	25-170	"	"	Gravel & Limestone	Dug, Drive & Drilled
T16N-R8E Sec. 35	30-85	"	"	Gravel-Limestone at 170'	Driven & Drilled
T16N-R8E Sec. 33	15-200	"	"	Gravel-Limestone at 240'	Driven & Drilled
T17N-R7E Sec. 20	20-40	"	"	Gravel	Dug & Driv
T15N-R6E Sec. 32	20-150	"	"	"	Dug, Drive & Drilled
T16N-R7E Sec. 5	40-200'	"	"	Gravel Limestone at 276'	Driven & Drilled
T17N-R5E Sec. 30	30-130	"	"	Gravel & Limestone	Driven & Drilled
T17N-R7E Sec. 24	20-110	"	"	Gravel & Limestone	Driven & Drilled
T16N-R6E Sec. 11	20-40	"	"	Gravel	Dug, Drive & Drilled
T16N-R6E Sec. 18	20-40	"	"	"	Dug, Drive & Drilled
T16N-R6E Sec. 35	25-80	"	"	"	Driven & Drilled
T17N-R8E Sec. 24	40-135	"	"	Gravel Limestone at 170'	Driven & Drilled
T17N-R8E Sec. 22	20-40'	"	"	Gravel	Dug & Driv
T17N-R8E Sec. 23	30-180'	"	"	Gravel & Limestone	Driven & Drilled
T17N-R8E Sec. 31	20-180	"	"	Gravel & Limestone	Driven & Drilled

ocation	Depth	Quality	Quantity	Formation	Construction
illow	20-80			Gravel	
	180			Limestone	
ilkinson	30-100			Gravel	
	180			Limestone	
arrington	20-40			Gravel	
hirley	40-135			Gravel	
	170			Rock	
hiladelphia					
	25-80			Gravel	
t. Comfort	20-40			Gravel	
ohawk	20-40			Gravel	
clners					
orners	20-110			Gravel	
	100			Limestone	
cCords-ville	30-130			Gravel	
	100			Limestone	
axwell	40-200			Gravel	
	276			Limestone	
one	20-150			Gravel	
don	20-40			Gravel	
levelend	15-200			Gravel	
	240			Limestone	
harlottes-ville	30-85			Gravel	
	170			Limestone	
ortville	25-80			Gravel	
	170			Limestone	
ew					
lestine	15-125			Gravel	
	285			Limestone	
reenfield	20-45			Gravel	
	220			Limestone	

MINERAL ANALYSES OF WATERS IN HANCOCK COUNTY (115)

(Parts per million)

Location	Geological Conditions	Iron	Aluminum	Silica	Calcium	Magnesium	Sodium	Potassium	Carbonate Radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
Fortville	Gravel	.60			100	21				172	65	1			15	280
Fortville	Gravel	.80			74	21				324	26	2	.3		2	370
Fortville	Limestone	1.2			73	24				266	23	2	.2	.002	2	348
Greenfield	Limestone	1.2	6		48	30	23			344	6.2	7	1.5			326

(115) U. S. G. S. Water-Supply Paper No. 254, p. 143

H A R R I S O N C O U N T Y

GENERAL FEATURES

Area 486 square miles. Population 17,254 (Census of 1930)

Harrison County is located in central southern Indiana on the Ohio River. The county seat is Corydon.

The maximum altitude in the county is 980 feet above sea level, the minimum is 360 feet, thus giving a total maximum relief of 620 feet. The maximum local relief is 610 feet, the greatest of any locality in Indiana. The entire county is quite rugged. The county is included in the Mitchell Plain, with the exception of the western one-third which is included within the Crawford upland. The Mitchell Plain area consists of undulating plains cut by few streams, but characterized by sinkholes and subterranean drainage. The extreme eastern portion of the county is underlain by rocks of the Borden group, the erosion of which has resulted in knob-like topography. The western one-third is characterized by sinkhole topography, and isolated remnants which form ridges and diversified topographic forms.

Drainage.-- Blue River forms the western boundary of Harrison County. It collects some surface water from the western part of the county through several short tributaries. Much of the drainage in the western and central parts of the county is subterranean.

Big Indian Creek, with its tributaries, Corn Creek from the north and Little Indian Creek from the northeast, carries the surface waters from the northeast and south-central portions of the county. This stream is a tributary of the Ohio River, which forms the southern county boundary. Water is carried to the Ohio from the eastern and southern parts of the county through Buck Creek and its branches; Middle Fork and South Fork. Mosquito Creek, another branch of the Ohio, drains an area in the southeastern part of the county.

GEOLOGY

Harrison County is within the unglaciated area of southern Indiana. The residual soils and deposits of alluvium along streams constitute the unconsolidated deposits. They are of little importance from the standpoint of ground water.

The bedrock formations which outcrop in the county are all of Mississippian age. From east to west these formations are the Borden, Harrodsburg, St. Louis, Ste. Genevieve, and Chester. These various formations dip to the westward, except where local structural irregularities occur.

Generalized Geologic Section for Harrison County

Quaternary:	
Recent, -- chiefly alluvium	0- 35'
Pleistocene, -- along Ohio River	150'
Tertiary: chert gravels	0- 80'
Mississippian:	
Chester, --	200'
Ste. Genevieve, --	140'
St. Louis, --	150'
Salem: --	40'
Harrodsburg, --	75'
Borden: --	500'
Rockford, -- Limestone	5'
Devonian: (Not Exposed in Harrison County, known from well records only)	
Silurian: (Not exposed in Harrison County, reported from well logs)	
Ordovician: (Not exposed)	

GROUND WATER

The only alluvial deposits of importance with respect to water supply possibilities are those along the Ohio River, and along the lower courses of the larger streams of the county.

Malott (116) has described a formation which is as much as 50 to 80 feet in thickness which may be tertiary in age, and which occurs as remnants on high divides in Harrison and Washington counties. The formation consists of loose sand, much cross bedded and locally contains white quartz pebbles. From the standpoint of ground water it is of local importance only.

(116) Malott, C. A., Physiography of Indiana, Part II, Handbook of Indiana Geology, Publication No. 21, Dept. of Conservation, State of Indiana, 1922. pp. 132-136.

The bedrock formations of the county contain water in varying quantities. Many natural springs are used. The cavernous condition of the limestones with subterranean drainage developed makes shallow wells difficult to obtain where those formations underlie the surface. Frequently joint planes and cavities are penetrated which yield and abundance of water. The Borden formations of the southeastern edge of the county do not contain available water.

Many wells drilled for oil and gas in this county have obtained salt and sulphur waters in formations underlying the Borden, so it is likely that deeper drilling will never obtain adequate water supplies. Shallow wells, impounding reservoirs, streams, and cisterns will continue to supply Harrison County with water.

Water Supplies of Towns in Harrison County

Lanesville.-- (population 273) The town of Lanesville btains a municipally owned water supply from a natural spring. he Harrodsburg formation outcrop in Little Indian Creek earby, also the Salem, and St. Louis formations. The exact tratigraphic position of the spring is unknown, other than his general information presented.

Croydon.-- (population 2,009) The town of Corydon btains a public water supply from Big Indian Creek. The town wns and operates the system.

Other incorporated towns in Harrison County include illtown, Laconia, Mauckport, Crandall, Palmyra, Elizabeth, ew Amsterdam, and New Middletown. None of these towns has a ublic water supply system.

HENDRICKS COUNTY

GENERAL FEATURES

rea 408 square miles Population 19,725 (Census of 1930)

Hendricks County is located in central Indiana. It is the irst county west of Marion County, in which Indianapolis is ocated. Danville is the county seat.

The maximum altitude of the county is 1,010 feet above sea evel, and the minimum is 685 feet, thus giving a total maximum elief of 325 feet. The maximum local relief is 120 feet. The rea of the county as a whole is a somewhat uneven plain and in eneral is little cut by streams. The county is a portion of he broad plateau-like area on the divide bet een the Wabash and hite Rivers and known as the Tipton Till Plain. The surface f the county slopes from the northwestern to the southeastern orner. A low, broad, belt of moraine has a north-south trend ross the county, slightly west of the center. The relief of he southern portion of the county is much more pronounced, also he drainage is better developed. The northern part of the ounty has poor drainage with artificial drainage much used.

Drainage. -- Hendricks County lies within the White River rainage basin. Eel River, a branch of the West Fork of White iver, crosses the northwestern part of the county. It has hree tributaries which enter or lie within the county, West ork, East Fork, and Ramp Run. Mill Creek and its tributaries rain the southwestern portion of the county. The tributaries e West, Middle and East Forks. White Lick Creek flows through he eastern part of the county. Near the south boundary, a ributary stream is West Fork of White Lick Creek which drains e central part of the county. The extreme southeastern corner the county is drained by the East Fork of White Lick Creek.

GEOLOGY

The unconsolidated deposits of Hendricks County consist of acial drift and alluvial deposits in stream valleys. The incipal alluvial beds are located in the valleys of Big and ttle White Lick Creeks.

Glacial till plains occupy most of the surface of the county, th the morainal belt crossing the county from northwest to utheast, west of the center of the county. The thickness of e drift varies considerably. Capps in Water-Supply Paper No 4 of the U. S. Geological Survey reports that in the south- stern corner of the county the drift is generally less than

75 feet in thickness, but the depth to bedrock increases to the north and east until it reaches more than 200 feet in the deepe places. Both Illinoian and Wisconsin glaciations transgressed this county, though the Wisconsin drift has given the present surface form, together with erosion in post glacial times.

The bedrock underlying the drift in Hendricks County consists of strata of Devonian and Mississippian age. The New Albany shale of Devonian age forms the bedrock for the northeastern corner of the county. East of a line extending approximately northwest through a point just west of Bridgeport, Marion County to Brownsburg in Hendricks County, the underlying formations are of Devonian age.

Most of the county is underlain by strata of Mississippia age and belong to the Borden subdivision. The bedrock dip to the southwest.

Generalized Geologic Section for Hendricks County

Quaternary:	
Recent, -- chiefly alluvium	0- 35
Pleistocene, -- glacial drift	0-150
Mississippian:	
Borden, -- siltstones, shales, clays	0-700
Rockford, -- limestone	0- 5
Devonian:	
New Albany, -- shale	100-150
Middle Devonian, limestones (From well records)	0- 65
Silurian: (From well records)	235
Ordovician: (From well records) Cincinnatian series	543

GROUND WATER

Alluvial deposits furnish supplies of ground water in area along the principal streams of the county. The Pleistocene glacial deposits are aquifers and provide most of the ground water to wells in the county. The till is predominantly clay, however, water occurs in the drift and will furnish domestic supplies. Drilled wells which go to greater depths usually penetrate gravel and sand beds of the till and produce more wa Frequently the gravels and sands are found near the surface.

The Devonian black shale underlying drift in the northeastern part of the county is not an aquifer. It is relativel impervious. Wells must either utilize waters from the overlyi drift, or drill to the deeper limestones of the Devonian and Silurian. A portion of the Indianapolis supply is obtained from these limestones and this horizon should bear potable waters in Hendricks County.

The Borden group of rocks which underlies most of the ounty is also relatively impervious and no adequate supplies of round water will be obtained from it. Seep wells, which will requently bear salty water will result when holes are drilled nto the siltstones and shales of the Borden. In the western rtion of the county, the deeply buried Devonian and Silurian mestones are likely to contain highly mineralized waters unfit r consumption. These formations produce the renowned rtesian" waters at Martinsville, which is along the strike of e formations encountered in the very southwestern corner of ndricks County. Near the outcrop of these Devonian and lurian formations the waters are good, but down the dip and distance from the outcrop or at distance from the contact of e formations and the drift, the waters are usually mineralized.

Water Supplies of Towns in Hendricks County

Pittsboro.--(population 489) The town of Pittsboro owns is public water system. Tubular wells are the source of the ter.

Danville. -- (population 1930) The town of Danville owns d operates its water system. Ten wells produce the supply. e water is reported to be obtained from limestone, which is und at depths from 110 to 165 feet, depending upon the topo- aphic location. The water is pumped to a standpipe and dis- ibuted by gravity. The writer is inclined to question the ported stratigraphic source of the water. The Borden group derlies the drift and valley filling at Danville. It is lieved that the Danville wells have penetrated some hard ratum in the upper portion of the Borden of that area and at the water comes from the drift. The Borden would never oduce adequate supplies for a town the size of Danville.

Plainfield. -- (population 1,617) The town of Plainfield ns and operates its water system. The supply is obtained om tubular wells, depth unknown. Water stands within 15 feet the curb. The wells were drilled in 1912. The water is ported to contain traces of iron and sulphur. Natural springs e abundant in the vicinity of Plainfield. For many years g and driven private wells furnished the citizens with water. e Indiana Boy's School near Plainfield obtained drinking ter from a large spring which issued from the side of a gravel race. Other supplies were obtained from a deep well. The g of this well is as follows:

Soil and brown sandstone	12'
Bluestone	58'
Bluestone	160'
Red shale	18'
Brown limestone	52'
Limestone	300'
White stone	3½'
TOTAL	603½'

Brownsburg. -- (population 1,042) The town of Brownsburg owns its water supply system. One well produces from the gravel of the drift at a depth of 163 feet. The drift is reported to be 250 feet in thickness here. The well is a ten inch well and water rises to within a few feet of the surface. It was drilled in 1923 and furnishes an abundance of good water.

The towns of Amo, Coatsville, North Salem, Stilesville, Clayton, and Lizton do not have public water supply systems. Th glacial drift is the chief source of supply in these towns.

Typical Wells in Hendricks County

Location	Depth	Quality	Quantity	Formation	Construction
T15N-R1W Sec. 10	20-112'	Hard	Good	Gravel	Dug & Drilled
T15N-R1E Sec. 27	20- 30	"	"	"	Driven & Drille
T17N-R1W Sec. 36	20-100	"	"	"	" "
T16N-R1E Sec. 11	30-150	"	"	"	" "
T15N-R2W Sec. 31	18- 30	"	"	"	" "
T16N-R2W Sec. 4	15- 75	"	"	"	" "
T15N-R1E Sec. 2	15- 30	"	"	"	Dug & Driven
T15N-R1W Sec. 35	10-150	"	"	"	Dug,Driven & Drill
T15N-R1E Sec. 31	40-110	"	"	"	Driven & Drille
T14N-R1W Sec. 25	20- 70	"	"	Gravel & rock	Dug, Driven & Drilled
T15N-R1W Sec. 35	10-140	"	"	Gravel & shale	Dug, Driven & Drilled
T14N-R2E Sec. 17	15-175	"	"	Gravel	Driven & Drille
T15N-R2W Sec. 22	15-140	"	"	"	" "
T14N-R1W Sec. 34	10-100	"	"	"	" "
Jappa	15- 50	"	"	"	" "
T17N-R1W Sec. 28	10-150	"	"	"	" "
T16N-R1W Sec. 23	10- 30	"	"	"	" "
T16N-R1W Sec. 7	10- 45	"	"	"	" "
T15N-R2W	10- 80	"	"	Gravel & rock	" "

ocation	Depth	Quality	Quantity	Formation	Construction
15N-R1W					
Sec. 31	12- 30	Hard	Good	Gravel	Driven & Drilled
17N-R1W					
Sec. 34	5- 30	"	"	"	" "
15N-R2W					
Sec. 30	12- 30	"	"	"	" "
14N-R2W					
Sec. 22	10-245	"	"	Gravel & sandstone	" "
16N-R1E					
Sec. 16	15-150	"	"	Gravel	" "
anville	20-112			"	
lainfield					
	20- 30			"	
Boys School)					
	603			Limestone	
rownsburg					
	30-150			Gravel	
ittsboro	20-100			"	
atsville	18- 30			"	
rth Salem					
	15- 75			"	
io	15- 30			"	
lleville					
	10-150			"	
rtersburg					
	40-110			"	
nter Valley					
	20- 30			Gravel--In rock at 70'	
ayton	10- 50			Gravel--In shale at 140'	
iendswood					
	15-175			Gravel	
dley	15-140			"	
zelwood	10-100			"	
ppa	15- 50			"	
zton	10-150			"	
plewood	10- 30			"	
nt Clair					
	10- 45			"	
W Winchester					
	10- 50			Gravel--In rock 30-80	
cksburg	12- 30			Gravel	
ntown	15- 30			"	
io	12- 30			"	
lesville					
	10- 20			"	
	245			Sandstone	
den	15-150			Gravel	

MINERAL ANALYSES OF WATERS IN HENDRICKS COUNTY (117).

(Parts per million)

Location	Geological Conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	Color	Total Solids
Brownsburg	Gravel		.10		165	53			438	242	118	5	.001	4	1066
Brownsburg	Gravel	19	1.8		62	27	37	Tr.	348	2.8	27	.7			405
Clayton	Shale				355	25			331	67	20			2	408
Danville	Gravel	16	2.1		32	26	58		360	4.3	3.2	9		4	349
Jamestown	Limestone		.2		46	28			378		38	.20	.001	4	548
No. Salem	Limestone		2.4		59	27			434		24	.05	.001	4	404
Pittsboro	Gravel		.1		156	58			419	173	172	12	.001		1244

(117) Water-Supply Paper 254, U. S. G. S. p. 149.

H E N R Y C O U N T Y

GENERAL FEATURES

ea 397 square miles Population 35,238 (Census of 1930)

Henry County is located in the eastern-central part of the ate. It is the fifth county north of the Kentucky-Indiana ate line and the second west of the Indiana-Ohio State line. castle is the county seat.

The maximum altitude of Henry County is 1,150 feet above level and the minimum altitude is 880 feet, thus giving a al maximum relief of 270 feet. The maximum local relief is feet. Henry County is within the Tipton Till Plain area Indiana. It is one of the highest counties in the State and entirely covered with Wisconsin glacial deposits. A morainal t extends from the southwestern part of the county to the theastern part. This belt is four to five miles across and ers a considerable portion of the northeastern part of the nty. The south central part of the county also has a separate distinct morainal belt which extends southward into Rush nty.

Drainage. -- The larger part of the drainage of Henry nty belongs to the White River area. A small part in the theastern portion of the county is within the Whitewater in. The northern portion of the county is drained by Pell ek and Mud Creek which flow northward into the West Fork of te River. The northwestern corner is drained by Fall Creek, ranch of the West Fork of White River. The extreme northeast- portion is drained by Stony Creek, a small tributary of Fall ek.

Blue River, a small tributary of the East Fork of White er, rises in the northeastern part of the county and flows ough the county in a southwesterly direction. Big Flat Creek es in the eastern part of the county and flows southwestwardly direction parallel with the Blue River. Small branches of Whitewater River receive the drainage of a small portion he southeastern part of the county.

GEOLOGY

The unconsolidated deposits of Henry County consist of the ial drift which mantles the county, and the alluvial deposits g the major streams. The drift of the county varies in kness. Near Middletown wells have logged 207,178, 127, 206, and 165 feet of drift. A well at Newcastle logged 333 of drift, another logged 535 feet. This is thickest drift rted in the entire State of Indiana. At Mr. Summit a well

recorded 230 feet of drift; at Springport a well logged 156 feet at Spiceland, 151 feet; at Knightstown only 64 feet; at Lewisville, 247 feet; at Cadiz, 421 feet, at Moreland, 150 feet; and at Kennard, 247 feet of drift. The surface irregularities which existed when the Pleistocene deposits were laid down were very marked in this area.

The bedrock strata of Henry County are of Silurian age, with the exception of the very extreme southeastern corner of the county. In a creek valley occur outcrops of Ordovician age. Cumings and Shrock (118) have described the quarry industry of

(118) Cumings, E. R., and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75. Dept. of Conservation, State of Indiana, 1928, p. 172.

this county as follows:

> "A lone quarry in Henry County, long since inactive, has been reported (Kindle, 1904, 427) at Quarry Mills, on Blue River, three miles southwest of Greensborough. The stone, which is an even-bedded, blue crystalline limestone was quarried along the river and used for building stone and burned for lime. No exposure of the rock is now visible, the only opportunity of seeing the stone being in the formation of the mill near the old quarry site. The stone is Silurian in age, but its exact horizon is not known."

Generalized Geologic Section for Henry County

Quaternary:	
Recent, -- alluvium and residual soils.	0- 30
Pleistocene, -- glacial drift	0-535
Silurian: Limestones and shales.	150-250
Ordovician: (Only few feet exposed)	
Cincinnatian series: Determined from well logs	543

GROUND WATER

Springs occur in Henry County, especially near streams. An impervious layer usually underlies a water-bearing bed and where the outcrop is down the dip from sources of water accumulation, springs result. Ground water may be obtained from a number of stratigraphic horizons in Henry County. The alluvial deposits along the streams and the drift accumulations afford the best sources of ground water. Usually an unfailing supply can be obtained from these sources. Wells which furnish water for domestic supplies are sunk into the drift for a distance of 20 to 100 feet. Those wells which penetrate gravel lenses in the drift secure the greater supplies of water, though the ground moraine or boulder clay will also furnish water but more slowly.

The Silurian limestone immediately underlying the drift is source of good water supplies. The water occurs in joints, vices and along the bedding planes. Many wells in this county ure water from this horizon. Usually it is not necessary penetrate deeply into the limestone formation.

Little is known of the character of the water from the ovician strata, which lie still deeper, in this county. The ord of a well drilled at Knightstown reports fresh water in so-called Trenton. The Trenton is the oil and gas producing izon in this section of Indiana. Salt water is the usual ng in the Trenton formations, so it is exceptional if fresh er did occur in the Trenton.

Water Supplies of Towns in Henry County

Newcastle. -- (population 14,027) The city of Newcastle owns operates its water supply system. Five wells obtain water m glacial drift at a depth of 105 feet. Three of the wells 10 inches in diameter, two are 12 inches in diameter. A few wing artesian wells are reported in this city.

Knightstown. -- (population 2,209) The town of Knightstown s its water system. Five wells which produce from a depth of foot furnish the water. The source is limestone of Silurian . The contact between the drift and the bedrock is usually excellent water horizon. Private wells find water at depths n 20 to 58 feet.

Lewisville. -- (population 442) The town of Lewisville owns water system. Two flowing artesian wells producing from stone at a depth of 50 feet supply the town. Other wells ort a thickness of 247 feet of drift in the vicinity of Lewis-le.

Mount Summit. -- (population 274) The town of Mount Summit its water system. The supply is obtained from tubular wells.

The following towns in Henry County maintain no public r supply systems: Mooreland, Straughn, Greensboro, Kennard, z, Sulphur Springs, Springport, Dunreith, Spiceland, and ntsville. Glacial drift is the source of supply for private s in the majority of these towns.

Location	Depth	Quality	Quantity	Formation	Construction
T16N-R9E					
Sec. 19	30'	Hard	Good	Gravel	Dug
Sec. 29	80-100'	"	"	Gravel	Drilled
T17N-R9E					
Sec. 3	20- 30-100'	"	"	Gravel & Lime	Driven & Drilled
Sec. 3	15- 35-150'	"	"	Gravel & Limestone	Driven & Drilled (Kennard)
Sec. 25	16- 20-150'	"	"	Gravel & Limestone	Driven & Drilled
T18N-R9E					
Sec. 19	20'	"	"	Gravel	Dug (Honey Creek)
Sec. 14	50'	"	"	Gravel	Drilled
Sec. 16	34'	"	"	Gravel	Drilled
T19N-R10E					
Sec. 21	240'	"	"	Limestone	Drilled (Mt. Summit)
Sec. 24	35'	"	"	Gravel	Dug
Sec. 28	80- 90'	"	"	Gravel	Drilled
T18N-R11E					
Sec. 20	20- 35'	"	"	Gravel	Drilled
Sec. 23	12'	"	"	Gravel	Driven (Mooreland)
T17N-R11E					
Sec. 17	31'	"	"	Gravel	Drilled
Sec. 24	40- 75'	"	"	Gravel	Drilled
T17N-R10E					
Sec. 13	40'	"	"	Gravel	Drilled
Sec. 25	57'	"	"	Gravel	Driven
Sec. 35	40'	"	"	Gravel	Drilled
T16N-R11E					
Sec. 27	30'	"	"	Gravel	Driven
T16N-R10E					
Sec. 25	57'	"	"	Gravel	Drilled (Lewisville)
Sec. 31	50-200'	"	"	Gravel & Limestone	Drilled (Dundreith)

HOWARD COUNTY

GENERAL FEATURES

rea 297 square miles Population 46,696 (Census of 1930)

Howard County is located in north-central Indiana. okomo, the county seat is 50 miles due north of Indianapolis.

The highest elevation in Howard County is 875 feet bove sea level and the lowest is 700 feet, thus giving a otal maximum relief of 175 feet. The maximum local relief is bout 55 feet. The average altitude of the county is 830 feet bove sea level.

The surface of Howard County is level to rolling. The olling land occurs on each side of Wild Cat Creek, which rosses the county from east to west. The valley of Wild Cat reek becomes wider as tributary streams are added westward. ld Cat Creek valley has been called a wedge of undulating urface which tapers from the smaller eastern end to the oad end of the wedge at the western margin of the county. rthern Howard County consists of broad flats and low swells d might be called typical prairie topography. The southern rt of the county is similar to the northern, however, more oken and the broad, flat area are more limited.

Drainage.-- The principal drainage basin of Howard unty is Wild Cat Creek. This stream has two branches, d Creek and Prairie Run, which assist in the drainage of e southeastern portion of the county. Three tributaries the Wild Cat Creek; Honey Creek, Little Wild Cat, and komo Creek drain the southern part of the county. Deer eek, a branch of the Wabash has small tributaries in the rthern part of the county. The extreme northeastern rtion of the county is drained by Honey and Pike Creeks, ributaries of Big Pipe Creek in Miami County. These waters into the Wabash.

GEOLOGY

The unconsolidated deposits of Howard County consist the alluvial deposits along Wild Cat Creek and its ger tributaries, and the glacial drift. The valley of d Cat Creek ranges in width from a few feet to as much one-half mile at the lower end. The alluvium varies n in thickness.

The moraines are low and inconspicuous. One belt of inal drift extends from Greentown northwest into Miami Cass counties, and Russiaville lies on another small ated portion.

The till is widespread over the entire county. The thickness varies from none where outcrops of bedrock occur to as much as 150 feet. The drift will average about 75 feet in thickness over the county, but the southwestern portion has thick drift. Where the drift is of moderate depth, it consists mainly of till, but the deeper portions include much sand and gravel in their lower part.

The bedrock strata of Howard County are of Silurian and Devonian ages. The rocks are primarily limestones. Cumings and Shrock (119) have outlined the distribution and

(119) Cumings, E. R., and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Department of Conservation, State of Indiana, 1928.

stratigraphic occurrence of the strata in this northern Indiana region. The succession from east to west across Howard County is as follows: Huntington limestone of Silurian age; Kokomo limestone of Silurian age; a tongue of Kenneth limestone extending northwestward from the vicinity of Kokomo which limestone is of Devonian age; Kokomo limestone of Silurian age; and then the western part of the county has a belt of Devonian limestones. This distribution is explained by the occurrence in the synclinal Logansport Sag.

Generalized Geologic Section for Howard County

Quaternary:
- Recent, -- chiefly alluvium . . . . . 0-50'
- Pleistocene, -- glacial deposits . . . . . 0-150'

Devonian:
- Middle Devonian, -- limestones . . (not exposed) 50-60' ?
- Kenneth, -- limestone . . . . . 0-20'

Silurian:
- Kokomo, -- limestone . . . . . 50'
- Huntington, -- dolomite ... (Not exposed)
- Liston Creek, -- limestone. (Not exposed)
- Mississinewa, -- shale... 10' exposed in Markland Avenue Quarry at Kokomo

Ordovician: (Not exposed)

GROUND WATER

Driven wells and dug wells are commonly used to procure water from the alluvial deposits. Near Kokomo wells in the bottom lands enter rock after penetrating the gravels and sands for 20 to 30 feet. The water table is near the surface and the flow or head from these wells is great. Many driven wells obtain sufficient water for domestic supplies.

In the morainal areas dug, driven, or drilled wells may be used. The gravel or sand beds between beds of till furnish the best waters. The till supplies most of the water used in the county. Many wells of large diameter, dug by hand and spade are used in this county. During prolonged drought

he water table lowers but deeper digging will reach it. If proper recautions regarding sanitation of the surrounding area are taken, uch wells may be safe. The deeper bored or drilled wells are to e preferred. Usually the till wells are not prolific producers, ut will supply adequate water for household and culinary purposes.

The bedrock of this county is primarily limestone, Many ells are drilled into the limestone, where potable and excellent upplies are obtained. The deeply buried Mississinewa shale of ilurian age are not an aquifer. Deep wells drilled in this county ould not produce potable waters.

Water Supplies of Towns in Howard County

Kokomo. -- (population 32,843). The city of Kokomo is furn-shed a water supply by the Kokomo Water Works Company, a privately ned organization. The water is from tubular wells drilled into e limestone formations. The limestone is penetrated from 15 to feet below the surface. Iron has been a characteristic mineral the Kokomo City supply and removal processes are in use at the esent time.

Greentown. -- (population 1,021). The town of Greentown is rnished water from tubular wells by a private organization. Bed-ck is reported at 80 feet, water stands at 40 feet. There are ree wells in use, eight inches in diameter. The producing stra-m is limestone.

Russiaville. -- (population 305). The town of Russiaville is pplied water by a privately owned company which procures water om tubular wells.

Typical Wells in Howard County

cation	Depth	Quality	Quantity	Formation	Construction
w London	20- 40'			Gravel	
lox	15- 60'			Gravel	
	60- 80'			Limestone	
evna	15- 65'			Gravel	
	65-120'			Limestone	
dgeway	20- 80'			Gravel	
	80-150'			Limestone	
camore	25- 60'			Gravel	
	60-125'			Limestone	
rmont	25-142'			Gravel	
	142-160'			Limestone	
st					
berty	15- 50'			Gravel	
	50- 85'			Limestone	
st					
ddleton	15-100'			Gravel	
	100-108'			Limestone	

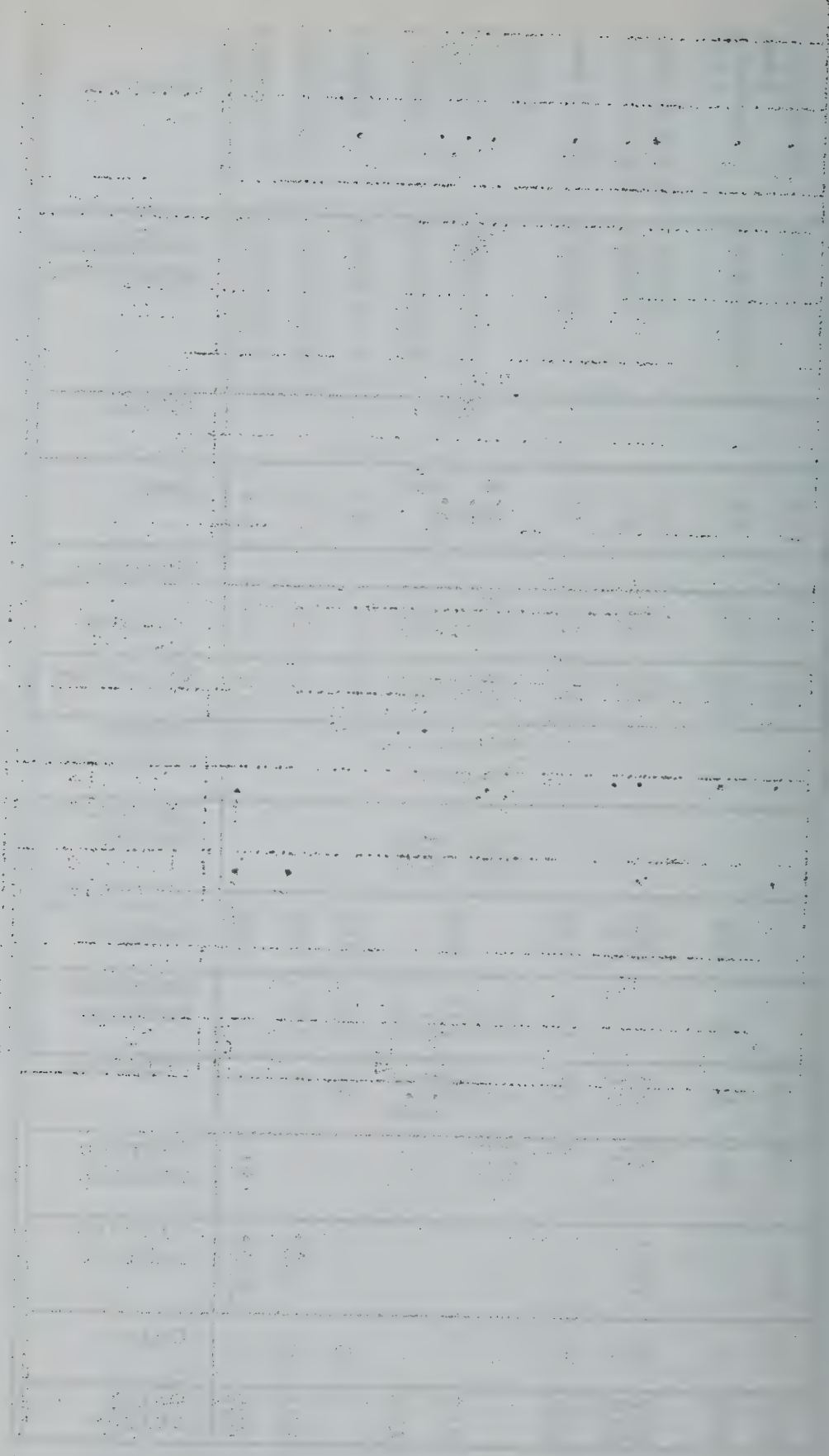
Typical Wells in Howard County (Continued)

Location	Depth	Quality	Quantity	Formation	Construction
T24N-R3E		Hard			
Sec. 25	15-500'		Abundant	Gravel & Limestone	Dug,driven, drilled
T24N-R5E					
Sec. 33	25-150'	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R2E					
Sec. 26	15- 40'	"	"	Sand & Gravel	Dug & driven
T24N-R4E					
Sec. 6	10-100	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R4E					
Sec. 15	15-135'	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R4E					
Sec. 20	15-110'	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R4E					
Sec. 26	20-115'	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R5E					
Sec. 11	20-125'	"	"	Gravel & Limestone	Dug, driven, drilled
T24N-R2E					
Sec. 14	20-150'	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R2E					
Sec. 14	20- 40'	"	"	Gravel & Limestone	Dug & driven,
T23N-R5E					
Sec. 25	15- 80'	"	"	Gravel & Limestone	Dug, driven, drilled
T24N-R4E					
Sec. 16	15-120'	"	"	Gravel & Limestone	Dug, driven, drilled
T24N-R2E					
Sec. 22	20-150'	"	"	Gravel & Limestone	Dug, driven, drilled,
T24N-R5E					
Sec. 35	25-125'	"	"	Gravel & Limestone	Dug, driven, drilled,
T24N-R4E					
Sec. 25	25-160'	"	"	Gravel & Limestone	Dug, driven, drilled,
T23N-R6E					
Sec. 19	15- 85'	"	"	Gravel & Limestone	Dug, driven, drilled
T23N-R3E					
Sec. 17	15-108'	"	"	Gravel & Limestone	Dug,
Kokomo	15- 30'			Gravel	ven, drille
	160-500'			Limestone	
Greentown	25- 95'			Gravel	
	100-150'			Limestone	
Russia-ville	15- 40'			Sand & Gravel	
Cassville	10-100'			Gravel	
	110'			Limestone	
Center	15-100'			Gravel	
	70-135'			Limestone	
Fairfield	15- 60'			Gravel	
	60-110'			Limestone	
Hemlock	20-100			Gravel	
	85-105'			Limestone	
Jerome	20-100'			Gravel	
	70-125'			Limestone	
Kappa	20- 90'			Gravel	
	90-150'			Limestone	

MINERAL ANALYSES OF WATERS IN HOWARD COUNTY (120).
(Parts per million)

Location	Geological Conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	Color	Total solids
Center	Limestone		1		46	30			288		5	.1.	.001	2	532
Hemlock	Limestone		2		61	27			360	27	4		.32	5	462
Kokomo	Limestone		.1		60	32			310	75	37			9	
Kokomo	Limestone		1		94	31		158		67	7.5				317
Kokomo			1.9		87	32	1 2	176		12	9.7				
Kokomo	Limestone	20	.4		63	32	2 5		367	114	32				372
Kokomo			2.3		122	45	3.4	223		23	52	1.4			
Kokomo					65	23	8.7	145		24	6	4.4			
New London	Gravel		.1		71	36			272	81	41	4		8	636
Russiaville	Gravel		.6		29	29			255		10	.05		1	378
Russiaville	Gravel		.8		70	31			298		98	.7	.001	12	360
West Liberty	Limestone		.8		83	27			304	58	7	.05		2	466
West Middleton	Gravel		.01		93	33			326		13	.1	.001	10	400

(120) From Water-Supply Paper No. 254, p. 157.



HUNTINGTON COUNTY

GENERAL FEATURES

Area 386 square miles Population 29,973 (Census of 1930)

Huntington County is located in the northeastern portion of Indiana. It is the third county west of the Indiana-Ohio State line, and the fourth county south of the Indiana-Michigan State line.

The maximum altitude of the county is 860 feet above the sea level and the minimum is 680 feet, thus giving a total maximum relief of 180 feet. The maximum local relief is 90 feet.

Physiographically Huntington County is included in two divisions. The southern two-thirds is a part of the Tipton till Plain and the northern one-third is a portion of the Steuben Morainal Lake Section. The southern portion is characterized by ground moraines, though the area is essentially flat. The general surface is marked by a rather inconspicuous recessional moraine known as the Salamonie moraine which enters the county at the southeastern corner and trends northwest to the center of the county and then strikes northeast toward the central northern boundary of the county. In the vicinity of the Wabash River this moraine is not conspicuous. The Mississinewa moraine touches the very southwestern corner of the county, curves to the westward and again enters Huntington County at the northwestern corner.

The northern third of the county, north of the Wabash River, west of Huntington, and then north of the Wabash-Erie valley extending toward Fort Wayne is included in the Steuben Morainal Lake Section. The topography is of the swell and sag type, however, it is not pronounced.

Drainage. -- Huntington County lies within the Wabash River drainage basin. The Wabash enters the county near the center of the eastern boundary and trends a few miles northward during its westward course across the county. Three important streams enter the county and influence its drainage. The Little Wabash enters near the northeastern corner and flows southwestwardly to enter the Wabash near Huntington. The branches entering the Little Wabash from the northwest are Mill Creek, and Calf Creek. Those entering from the south are Eight Mile and Flat Creeks. The extreme northwestern corner of the county is drained by small branches of Eel River, North of the Wabash, two tributaries of that stream; Silver Creek and Prairie Creek flow southward into it. Loon Creek heads in the eastern part of the county and flows westward in a line almost parallel with the Wabash until it enters that stream near the western border of the county. Rock Creek, another southern branch of the Wabash, drains a small area in the eastern part of the county. The southern portion is drained by the Salamonie

River and its tributaries. The Salamonie enters the county about four miles west of the southeast corner and flows in a northwesterly direction to enter the Wabash River in Wabash County. The Salamonie has a few northern branches and many small tributaries draining the southwestern part of the county.

GEOLOGY

The unconsolidated deposits of Huntington County consist of alluvial materials along the streams and of glacial deposits. The valleys are small with the exception of the old lake outlet which joins the Wabash near Huntington. In this old valley the deposits are probably of glacio-fluviatile origin whereas the Wabash has a narrow valley built up by stream aggradation.

The glacial drift in the county varies in thickness from 30 to 250 feet. At Roanoke wells enter rock at 36 feet. At Warren the limestone bedrock is penetrated at 50 to 100 feet. South of the old lake outlet the drift is comparatively thin, being ususally less than 100 feet. North of the Wabash the drift in many places is 200 feet or more in thickness.

The strata underlying the drift consist of Silurian rocks. Outcrops are quite numerous. Cumings and Shrock (121)

(121) Cumings, E. R., and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Department of Conservation, State of Indiana, 1928. pp. 174-175.

describe the quarry rocks of Huntington County as follows:

"Huntington County furnishes the greatest variety of rock materials of any county in the northern part of the State. Formations from the Mississinewa shale to the New Corydon limestone are exposed. In this county are found strata suitable for lime-burning, for road material, for flagging and for building purposes. Numerous quarries are found along and south of the Wabash Valley, but none very far north of Little River. One and one-half miles northwest of Warren, on the west bank of the Salamonie River, in the S. E. ¼ of N. W. ¼ of Section 19, T. 26 N., Range 10 E., lime was formerly burned from reef rock of Mississinewa and Liston Creek age. The quarry hole, now a public dump, will soon be obliterated. Exposures are still to be found, however, in the abandoned road which runs along the north side of the old quarry. A short distance downstream, on the same side of the river, the slabby Liston Creek limestone was once quarried from a small opening which has long since become overgrown with underbush. Near Lancaster, on the east bank of the Salamonie River, in the S. E. of S. E. ¼ of Sec. 33, T. 27 N., R. 9 E., a small quarry was opened in the highly inclined strata of a reef in the Mississinewa shale, but the difficulty encountered in quarrying the inclined strata

used the opening to be abandoned. The stone was crushed
d used locally. The crusher is still intact. At Markle,
the east part of the county, along the Wabash River,
ere was at one time considerable activity in quarrying.
the present time, however, all the openings are abandoned
d filled with water. These quarries were all in reef-
ank strata of Mississinewa and Liston Creek age. The
one was used for lime (Blatchley, 1904, 239-240) and for
ad purposes. At Huntington is found one of the most
tensive quarry districts in the northern part of Indiana.
re stone is being quarried for both lime burning and road
d railroad ballast material. In the past Huntington was
important center of lime manufacture, but today only
e quarry is being worked. More, however, will be said
out the lime industry later. In the S. W. ¼ of Sec. 12,
28 N., R. 9 E., the Erie Stone Products Company (France
mpany) is working a very large quarry in the Liston Creek
mestone. The quarry covers some 20 to 25 acres and
ries from 30 to 60 feet in depth. The Mississinewa
ale was encountered at a depth of 60 feet, so that
eper quarrying will probably not be undertaken. Much stone
yet available, however, where the quarrying has not
ached the shale. The stone quarried here is a hard,
erty limestone, very massive when first exposed but dis-
tegrating like poor concrete on exposure. The crushed
one finds a good local market for concret work and road
ilding, and is also shipped to distant points. Its chief
e is for road material. Quarrying ceased this year dur-
g the winter months, but will be resumed when summer
mes. Small openings have been made in the Liston Creek
mestone at several points within the city limits of
ntington. In the west part of the city, along the north
nk of Little River, near the Memorial park and cemetery,
e several abandoned quarries. One, in the heart of a
ef, has now been transformed into a sunken garden and
kes one of the beauty spots of the park.

"Numerous other openings have undoubtedly been made
om time to time in the various limestones along the
abash Valley to supply local needs. These openings were
equently in isolated locations and did not become very
idely known."

The Liston Creek limestone underlies almost three-
urths of the area of Huntington County. The Mississinewa
le underlies the Liston Creek and outcrops in the valleys
the Salamonie and Wabash. The northeastern quarter of the
unty is underlain by the Huntington dolomite.

Generalized Geologic Section for Huntington County

ternary:
Recent, -- alluvium . . . . . 0-40'
Pleistocene, -- glacial deposits. . . . . 0-150'
urian:
Huntington, -- dolomite . . . . . 180'
Liston Creek, -- limestone . . . . . 60'

Mississinewa, -- shale . . . . . 250'
Ordovician: (Not outcropping)

GROUND WATER

The valleys of the county are small, hence the alluvial deposits are not of wide extent. The old lake outlet which joins the Wabash near Huntington has a width of one to two miles northeastward through the county. The deposits vary from 40 to 75 feet in depth. Above the junction of the Wabash and the Salamonie, the former's valley flat is less than one-eighth of a mile in width and the deposits are not thick. Locally the alluvium is of importance as a source of water. The old valley flat or lake outlet is a good source of water.

The Silurian limestones which underlie the drift are excellent aquifers. The Huntington dolomite is porous at the surface or at the drift contact. Many wells in the county procure water from this horizon.

The drift of the county is mainly a compact till. Wells are obtained either in local deposits of gravel and sand within the till or more extensive deposits which appear to prevail near the base of the drift. Leverett (122) has

(122) Leverett, Frank, Wells of Northern Indiana, U. S. Geological Survey, Water-Supply and Irrigation Paper No. 21, 1899. pp.54-55

given some information concerning individual wells as follows:

"Wells on the plain north of the Wabash outlet have in a few cases, entered rock at about 140 feet, after penetrating a nearly solid sheet of till. Ordinarily, the wells are but 50 to 100 feet and encounter no rock.

"In the city of Huntington, on the uplands bordering the lake outlet, wells are frequently obtained at about 30 feet in gravel below the till. Along the outlet they are usually sunk into the limestone, which there outcrops quite extensively. The waterworks wells are sunk into the limestone to a depth of about 100 feet. Although there are eleven wells in use, the supply is insufficient and some water is pumped from the river.

"Above Huntington, in the vicinity of Roanoke, wells in the old lake outlet are often obtained without entering rock, at depths of 10 to 25 feet. One well near Roanoke enters rock at 36 feet.

"In the vicinity of New Lancaster, on the borders of the Salamonie River, gravel is more abundant than elsewhere along the valley and wells often obtain water without penetrating till. Between New Lancaster and Andrews wells commonly penetrate 20 to 40 feet of till.

"At Andrews the wells are usually carried into the imestone at depths of 60 to 150 feet, and occasionally to ver 200 feet. The analysis of water from a well in this illage is given in the Eighteenth Annual Report U. S. eology Survey, Part IV, p. 498. The well is 214 feet in epth. The water is shown to be slightly saline as well as ard. It also contains much sulphureted hydrogen."

"In the vicinity of Warren several flowing wells have een obtained in limestone on low ground along the alamonie River at a depth of 65 to 100 feet. The head s sufficient to carry the water only 5 or 6 feet above he surface. The water is decidedly chalybeate."

Water Supplies of Towns in Huntington County

Huntington. -- (population 13,420) The city of ntington owns its water system. The source of the water tubular wells.

Markle. -- (population 621) The town of Markle owns d operates its water system. One well produces from the mestone which is penetrated at 15 feet. The well is eight ches in diameter.

Warren. -- (population 1,177) The town of Warren owns s public water supply, which is obtained from two wells illed into limestone, penetrated at 20 feet. The wells in is locality are reported to lower some 6 to 7 feet during y seasons.

Roanoke. -- (population 849) The town of Roanoke owns s water system. Six wells produce from limestone, penetrated 33 feet. Water stands at 20 feet.

Andrews. -- (population 883) The town of Andrews owns s water supply, obtained from tubular wells.

Mount Etna. -- (population 135) The town of Mount Etna s no public water system.

Typical Wells in Huntington County

Location	Depth	Quality	Quantity	Formation	Constructi
T28N -R9E					
Sec.35NW¼	-118'	Hard	Good	Limestone	Drilled
T27N -R9E					
Sec.14NW¼	100	"	"	"	"
Sec.25NE¼	35-115	"	"	Gravel&Lime	"
Sec.33	65-105	"	"	Limestone	"
T26N-R9E					
Sec.9	112	"	"	"	"
Sec.27SW¼	70	"	"	"	"
T26N-R10E					
Sec.4NE¼	105	"	"	"	"
Sec.19SE¼	100	"	"	"	"
T27N-R10E					
Sec.1NE¼	267-286	"	"	"	"
Sec.21NE¼	98	"	"	"	"
T28N-R10E					
Sec. 9NE¼	59	"	"	"	"
Sec.21SW¼	100	"	"	"	"
T29N-R10E					
Sec. 12	145-145	"	"	"	"
Sec.18NE¼	100	"	"	"	"
T29N-R9E					
Sec.21	20	Soft	"	Sand&Gravel	Dug--Spri
T29N-R8E					
Sec.23	250	Hard	"	Limestone	Drilled-(
Sec.24	100	"	"	Gravel	"
T28N-R8E					
Sec. 2	127	"	"	Limestone	"
Sec.20SW¼	---	----	----	----	
Sec.26SW¼	60	Soft	Good	Sand	
Sec. 2	125	Hard	"	Limestone	
T27N-R8E					
Sec.23	42	Soft	"	Sand	
Sec.23N½	18-20	"	"	"	----
Sec.26NE¼	15-20	"	"	"	Driven
T26N-R9E					
Sec. 6	45-50	"	"	"	Drilled
Sec. 6	70	"	"	Gravel	Drilled
T27N-R9E					
Sec.33NW¼	---	Hard	"	Limestone	----
Sec.33SE¼	100	"	"	Gravel	----
T26N-R8E					
Sec.18SE¼	25	Soft	"	"	
Sec.19NE¼	65	"	"	"	
T29N-R9E					
Sec.9	32	"	"	"	Shallow well
Sec.9	140	"	"	Limestone	----
Sec.4	140	Hard	"		Shallow wel

Typical Wells in Huntington County (Continued)

Location	Depth	Quality	Quantity	Formation	Construction
T28N-R9E					
Sec. 2	130'	Hard	Good	----	
T29N-R9E					
Sec.26NW¼	150	"	"	Limestone	20' in rock
Sec.23NE¼	143	"	"	"	19' in rock
Sec.24SW¼	140	"	"	"	
Sec.22SE¼	150	"	"	"	
Sec.22NE¼	112	"	"	Gravel	
Sec.21NE¼	197	"	"	Limestone	
Sec.16SE¼	43	Soft	Fair	Gravel	
Sec.21	20	"	"	"	Springs

JACKSON COUNTY

GENERAL FEATURES

a 518 square miles Population 23,731 (Census of 1930)

Jackson County is located in southern Indiana. It is the rth county west of the Indiana-Ohio State line, and the rd county north of the Indiana-Kentucky State line. Browns- n is the county seat.

The maximum altitude of Jackson County is 940 feet above level, and the minimum is 495 feet, thus giving a total imum relief of 445 feet. The maximum local relief is 360 t. The county presents two distinct physiographic types. The tern two-thirds constitute a portion of the Scottsburg Low- nd and the western one-third is included in the Norman Upland. name of this latter unit is taken from Norman Station in ern Jackson County, where it is typically developed. Malott 5)has described the eastern division of the county as a portion

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5) Malott, C.A., Physiography of Indiana, Part II, Handbook of iana Geology, Publication No. 21, Dept. of Conservation, State ndiana, 1922, pp. 88-90.

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broad, shallow concavity broken by two or three outlets to west where streams pass out of the region. The valleys are d and flat and local relief is slight. In the western por- of the county, the Knobstone escarpment marks the boundary between the Norman Upland on the west and the Scottsburg and on the east. This escarpment is the greatest relief feat- and the most prominent topographic form in Indiana. The re- is great locally and stream action has maturely dissected region. The rocks underlying the Norman Upland region have responsible in part for the present physiographic develop - . This is also true of the Scottsburg Lowland unit.

The entire surface of Jackson County has been glaciated the exception of a small strip one to six miles in width the western boundary of the county.

Drainage. -- The East Fork of White River and the Muscata- River, a tributary of the former, form the boundary on the for Jackson County. The East Fork of the Muscatatuck forms boundary for the southeastern part of the county. The south- rn portion is drained by this stream, the Vernon Fork of the atatuck and its tributaries. The East Fork of White River s the county near the northeastern corner and flows south-

westerly to a point about eight miles east of the western boundary of the county. From this point it flows in a general weste direction and forms the southern county boundary. Grassy Fork i an important northern tributary of the Muscatatuck and flows parallel to the Vernon Fork to the west of that stream. The nor central part of the county is drained by White Creek which flows south into White River. The northwestern part of the county is drained by branches of Salt Creek, the most important of which i Muddy Fork. The western part of the county is drained by Guthri Creek, Back Creek, and their tributaries.

GEOLOGY

The unconsolidated deposits of Jackson County consist of a luvium along the major streams, glacial deposits and residual so

Alluvial materials are found along the East Fork of White River, the Vernon and East Forks of the Muscatatuck River, and t main Muscatatuck River, and locally along minor streams such as Muddy Fork, Grassy Fork and White Creek.

The glacial deposits cover the entire county with the exce tion of a narrow strip along the western border. Jackson County was covered only by the Illinoian glacier. The drift deposits a thin, and are frequently absent over large areas. One pronounce morainal ridge known as Chestnut Ridge begins some three miles south of Seymour and extends 8 miles in a southerly direction. The ridge is from one-half to one mile in width and rises from 5 to 170 feet above the lowlands.

The bedrock strata of Jackson County consist of formations of Devonian and Mississipian age. The Devonian rocks occupy a small area of about 40 square miles in the northeastern part of the county. The Mississipian strata cover the remainder of the area. The Rockford, Borden, Harrodsburg and Salem units are re cognized from east to west in the order of their outcrop across the county. The drift rests on the eroded surfaces of these for tions over most of the county, thus explaining the varying thick nesses of the drift.

Generalized Geologic Section for Jackson County

Quaternary:

Recent, -- chiefly alluvium	0-4
Pleistocene, -- glacial deposits	0-2

Mississipian:

Salem, -- limestone	0-
Harrodsburg,	0-
Borden,	0-
Rockford, -- limestone	2-

vonian:

New Albany, - - shale . . . . . 120'
Middle Devonian, -- limestones (Not exposed) . . . . . 65'

lurian: (No outcrops in Jackson County)

dovician: (No outcrops in Jackson County)

GROUND WATER

Ground water is obtained from springs and wells in Jackson unty. The alluvial deposits along the stream valleys are the ief aquifers of this county. Many private supplies are from allow wells and springs. Where the drift is of sufficient thick- ss good waters may be obtained, however, the drift in many areas thin or absent and frequently when capping ridges and hills the ound water escapes laterally into streams which have cut below e level of the containing beds.

The Borden group of the Mississipian which underlies most of e county is relatively impervious. A few springs come from the den, even some of these have mineralized waters. The Borden ata have been determined by Stockdale to be 685 feet in thick- ss at Rockford and 665 feet at Goss Mill. This is not actual ickness but based on projections of known outcrops. The rocks e of such fine texture that ground water does not circulate ough them readily. Wells drilled into the Borden will not ally furnish adequate quantities of potable water.

The Devonian shales which outcrop in northeastern Jackson unty dip to the southwestward and underlie the Mississipian for- ions. The Rockford of the Mississipian is a thin limestone and it is located between two relatively impervious formations, is believed to be of consequence as an aquifer. The New Albany ck shale is not an aquifer, though, it contains joints through ch water might move.

In the 18th Annual Report of the U.S.Geological Survey, Part Leverett describes a well bored for gas at Brownstown, The er from the Niagara limestone (Silurian) was sulphurous-magne- an water, and the water found in the St. Peter sandstone was ongly saline. He states that the bore penetrated the St. Peter y 47 feet and that the salt water was found at the bottom, and t perhaps adequate passage for the water may not have been hed.

It appears that the Silurian and Ordovician strata contain cralized waters and can never be considered a possible source potable supplies. The same is possibly true of the Devonian estones and shales. Early Indiana geological reports describe manufacture of salt. The 6th Annual Report of the Geological vey of Indiana made in 1874 by E.T.Cox, p. 53, describes cer- n salt springs along Muddy Creek, in the northwestern part of kson County. "At low water, several salt springs can be seen,

which break up from the bed of the creek. Thirty-five years ago a company sunk a well to this brine. The mouth of the well was below the overflow and it was not carried to any considerable depth. The brine did not prove to be very strong; twenty-five or thirty kettles were set and the manufacture of salt was prosecuted on a small scale for some years. The well has long since been filled up and the manufacture abandoned, but it is highly probable that stronger brine could be reached by boring down to the Genesee shale which might be reached here at from 100 to 150 feet."

The brine occurred in Borden rocks, though the black shale of Devonian age was also considered a possible source.

Fortunately Jackson County has several surface streams which may be utilized in the development of public water supplies. Springs, cisterns, and shallow wells drilled into drift and alluvium will continue to furnish private supplies.

Water Supplies of Towns in Jackson County

Brownstown. -- (population 1,758). The town of Brownstown is furnished a public water supply by the Interstate Public Service Company, a private corporation. A dug well is the source of the supply. The location of Brownstown in proximity to the flood plain of the East Fork of White River assures an excellent source of supply.

Medora. -- (population 654). The town of Medora has no public water system. The alluvial deposits in the White River bottoms would make an excellent source of supply.

Seymour. -- (population 7,508). The city of Seymour is furnished water by the Seymour Water Company, a private organization. The water is obtained from the East Fork of White River. Many private wells obtain supplies from wells 15 to 50 feet in depth.

Crothersville. -- (population 979). The town of Crothersville owns and operates its water system. Two wells are reported to furnish water from white and blue rock. Borden strata outcrop near Crothersville and it is quite possible that the water supply is associated with the Rockford limestone, basal Mississipian formation in Indiana. The New Albany black shale outcrops in the Muscatatuck River to the south of Crothersville. This area is in the ponded Muscatatuck area of Wisconsin glacial times and great thickness of alluvium occur. Bedrock is reported at 80 feet. It is likely that the alluvial gravels are the source of the water.

Typical Wells of Jackson County

Township	Section	Quality	Depth	Formation
Carr	SE¼ 30-5N.-4E.	Hard	23'	Gravel
"	NE¼ 36-5N.-3E.	"	18'	"
"	NW¼ 35-5N.-3E.	"	14'	"
"	Medora	"	10'-18'	"
"	SW¼ 27-5N.-3E.	Soft	------	Cistern
"	NW¼ 28-5N.-3E.	Hard	12'-14'	Limestone
"	NW¼ 29-5N.-3E.	----	------	Spring
"	SE¼ 19-5N.-3E.	Soft	------	Cistern
"	SW¼ 18-5N.-3E.	----	------	Spring
"	SE¼ 24-5N.-2E.	----	18'	--------
"	SW¼ 23-5N.-2E.	----	23'	--------

J A S P E R C O U N T Y

GENERAL FEATURES

rea 562 square miles Population 13,388 (Census of 1930)

Jasper County, the third largest county in area in Indiana s located in the northwestern portion of the State. It is the econd county south of the Lake Michigan, also the second county ast of the Illinois-Indiana State line. The maximum altitude f the county is 770 feet above sea level, the minimum is 640 eet, thus giving a total maximum relief of 130 feet. The aximum local relief is 55 feet.

The entire county is included in the Kankakee Lacustrine ection of the Northern Moraine and Lake Region of Indiana. The nkakee River which is the northern boundary of the county is esponsible to a large degree for the 15 or 20 miles of marshy, ndy, land which extends southward from the river. Sand ridges ver the southern margin of the marshy area. The central rtion of the county is traversed by Marseilles moraine which ends north eighty degrees east from the central-western border the county until east of Rensselaer. Then it turns north- st to the northwestern corner of Pulaski County. The southern rt of the county is a part of the Tippecanoe-Iroquois plain ich is sand-covered and in many places covered with drift.

Drainage. -- Jasper County lies mainly within the Kankakee sin. The Kankakee is the northern county boundary. Small ibutaries of this river drain the northern part of the county. e south and central parts of the county are drained by the oquois River, a tributary of the Kankakee, and its branches. e of these branches is the Pinkamink River which heads on the st central side of the county and flows southwestward. It ceives a tributary from the north, Ditch Creek. Big Slough eek flows into the Pinkamink from the west-central portion of e county. Alder Creek and Carpenters Creek drain the uthwestern portion of the county.

GEOLOGY

The unconsolidated deposits of Jasper County consist of uvium along the major streams, the glacial deposits, and the ustrine deposits. In the northern part of the county the ft deposits are 75 to 200 feet in depth, but in the central southern portions the drift deposits are generally quite n, there being only a coating of sand 10 to 20 feet in depth. some wells a hard till is found below the soft Wisconsin l. The lower till probably represents the Illinoian till.

Bedrock occurs at varying depths in Jasper County. At Rensselaer wells penetrate rock at 5 to 15 feet. Immediately west of Rensselaer the rock surface suddenly drops down 75 to 100 feet or more. In the southern end of the county the rock surface is higher above sea level than that at Rensselaer, though the drift is only 10 to 20 feet in thickness. On the crest of the moraine southeast of Surrey a well goes through 192 feet of drift. Two wells at Surrey report entering rock at about 90 feet. On the south side of the moraine near the eastern border of the county wells penetrate but 5 to 15 feet of drift. The southeastern portion of the county has thin deposits of drift.

The location of Jasper County on the crest of the Kankakee arch is the key to the stratigraphic distribution. From the present known distribution determined by a few outcrops and well records the major central northwestern-southeastern portion of the county is underlain by Silurian strata. The city of Rensselaer is near the southwestern margin of the Silurian belt, which extends ten miles northeastward. At its widest diestribution in the northwestern part of the county it is about 25 miles across. Devonian limestones and Devonian shale lie on the flanks of the arch, both northeastward and southwestward and both are represented on the two flanks in this county. The reader is referred to Publication No. 112, the 1932 edition of the geological map of Indiana.

Generalized Geologic Section for Jasper County

Quaternary:	
Recent, --	0-.60'
Pleistocene, -- clay, sand, gravel	0-100'
Pennsylvanian:	20- 30'
Mississippian:	
Borden, --	100'
Rockford, --	4 - 5'
Devonian:	
New Albany, -- shale	100'
Middle Devonian, -- limestone	25'
Silurian:	
Huntington dolomite exposed at Rensselaer, thickness unknown.	

GROUND WATER

Ground waters are found in sufficient quantities in fairly shallow wells to supply domestic needs. On the borders of the Kankakee marsh, in the northern part of the county, wells are usually obtained at shallow depths, 15 to 25 feet, in the sand deposits. In the belt of country occupied by the Marseilles moraine it is necessary to drill beneath the morainal covering to beds of sand and gravel within the till. Leverett reports a well on the moraine in Section 13, T. 30 N, R 5 W., which penetrated 102 feet of

drift, mainly blue till. In Section 1 of the same township a well had 126 feet of drift and another well in Section 2, same township, had 118 feet. In these three wells the water is obtained at slight depth into the underlying bed rock. It is not definitely known the exact stratigraphic horizon at which the water occurs. If the bedrock is limestone, it is believed to be Silurian (Huntington), or Middle Devonian limestone, and if shale it is possibly New Albany of the Devonian.

Wells in Section 3, Township 29 North, Range 5 West penetrate only 15 feet of drift until bedrock is struck. The bedrock is near the surface in certain portions of southern Jasper County. At Rensselaer, in the southeastern part of the city, two quarries are believed to start in the Devonian. Cumings and Shrock have suggested that deeper quarrying may expose the Huntington dolomite of the Silurian.

In the southern half of Township 27 North, Range 7 West, the rock surface rises to a greater altitude than in the vicinity of Rensselaer, according to Leverett, in the 21st Water Supply Paper of the U. S. Geological Survey. He further states that although the general elevation is about 50 feet higher than at Rensselaer and the portion of the county east from that city, the wells in this southern end of the county often enter rock at 10 to 20 feet. Wells for water in the vicinity of Rensselaer range in depth from 30 feet to 200 feet. They enter rock at 6 to 15 feet.

Inquiry in Jasper County of 22 residents of the source of their water supplies, showed that 13 obtained water from the limestone and 9 secured water from the glacial drift. These wells were widely scattered, in nine different townships. The wells ranged in depth from 15 to 200 feet.

At Remington the dug wells are usually 12 to 20 feet in depth, obtaining water near the base of the drift. According to Leverett the drilled wells are 75 to 125 feet in depth. He gives the following log:

Drift	18'
Shale	95 to100'
Solid stone	8 to 10'
Total	121 to128'

Water in the above well rose to within 18 feet of the surface and contained sulphureted hydrogen in small amount.

Water Supplies of Towns in Jasper County

Remington. -- (population 879) The town of Remington owns its water supply, obtained from one tubular well.

Rensselaer.-- (population 2,798) The city of Rensselaer has a municipal water supply. It is obtained from tubular

wells drilled into the limestone. Hydrostatic pressure raises the water level several feet in this vicinity.

Wheatfield. -- (population 401) The town of Wheatfield has no public water supply system.

Typical Wells in Jasper County

Location	Depth	Quality	Quantity	Formation	Constructio
T27N-R7W					
Sec. 9	200'	Hard	Good	Limestone	Drilled
Sec. 21	36'	"	"	"	"
T28N-R7W					
Sec. 9	20- 30'	"	"	Gravel	Driven
Sec. 32	90'	"	"	Limestone	Drilled
T29N-R5W					
Sec. 4	40-100'	"	"	"	"
Sec. 19	50'	"	"	"	"
T30N-R5W					
Sec. 36	30'	"	"	"	"
T28N-R6W					
Sec. 25	120'	"	"	Limestone	"
Sec. 18	18'	Soft	"	Sand	Driven
T28N-R7W					
Sec. 77	16'	"	"	"	"
T28N-R6W					
Sec. 18	100'	Hard	"	Limestone	Drilled
T30N-R6W					
Sec. 32	100'	"	"	"	"
T31N-R7W					
Sec. 25	200'	"	"	"	"
	(Other wells range from 10' to 100')				
T30N-R6W					
Sec. 19	82'	Hard	Good	Gravel	Drilled
Sec. 18	170'	"	"	Limestone	Drilled (84 in Limeston
Sec. 19	80'	"	"	Gravel	-------
Sec. 19	83'	"	"	Gravel	(Aix School house)
Sec. 19	15- 20'	Soft	"	"	(North of A in Kankake basin).
Sec. 19	15- 20'	"	"	"	(Kniman)
Sec. 19	15- 20'	"	"	"	(Wheatfield
Sec. 19	120'	Hard	"	Limestone	(Wheatfield
T31N-R6W					
Sec. 2	800'	"	"	"	(White sul water)

J A Y C O U N T Y

GENERAL FEATURES

Area 375 square miles Population 20,846 (Census of 1930)

Jay County is located in central eastern Indiana. Its eastern boundary is the Indiana-Ohio State line. It is the fifth county south of the Indiana-Michigan State line, Portland is the county seat.

The maximum altitude in the county is 1,120 feet above sea level, the minimum is 840 feet, thus giving a total maximum relief of 280 feet. The maximum local relief is only 100 feet.

Jay County is a portion of that vast gently rolling area of central Indiana, known as the Tipton Till Plain. The general slope of the surface is toward the northwest and west. Two pronounced belts of hilly, morainal topography cross the county. One moraine extends from the southeastern corner of Blackford County in a southeastwardly direction to the southeastern corner of Jay County. This is a portion of the Mississinewa recessional moraine. The second belt of moraine is known as the Salamonie recessional moraine. It extends from the central and south-central part of the east side of the county in a general northwesterly direction and leaves Jay County at the northwestern corner. The remainder of the county consists of till plain, which is gently rolling.

Drainage. -- The extreme northeastern corner of the county is crossed by the Wabash River, which with its tributaries drains the central northern and northeastern portions. The tributaries are Ditch, Bear, and Limberlost Creeks, also Bettle Ditch.

The Salamonie River heads in southeastern Jay County and flows northwestward across the county. Mud Creek and Brooks Creek are southern branches of the Salamonie. Haines and Beaver Creeks are tributaries in the northwestern portion of the county. Buckeye Creek flows northward into the Salamonie in the southeastern part of the county. The extreme southern portions of the county are drained by small tributaries of the Mississinewa River.

GEOLOGY

The unconsolidated deposits of Jay County consist of alluvium and glacial deposits. The alluvium consists of fans formed at the bases of steep slopes and the valley flats of streams. Artificial dredging has destroyed the flood plains in many places. The drift of the county consist of ground moraine and recessional moraine, kames, eskers, and character-

istic kettle topography with its resultant depressions. When Jay County was first settled the undrained depressions in the morainal topography were full of water, some of the "kettles" remaining filled with water for the entire year. It is a little difficult to conceive at the present time and under the present surface configuration that at one time portions of the county were swampy. When the Indiana Department of Geology surveyed the county about 1912, in preparation of a soil map, only one swamp area was mapped. This was located in Section 4, Township 24 North, Range 13 East. Jay County has been more interested in disposing of ground water which stood so near the surface, than it has in procuring wate

A. D. Hole (124) has written as follows concerning the

(124) Hole, A. D. Soil Survey of Jay County, 38th Annual Repor Indiana Department of Geology and Natural Resources, 1914. p.

marsh land of Jay County:

"At a few points in the county marsh land exists, but at one point only is the area sufficiently large to be mapped, namely in Section 4, Township 24 North, Range 13 East,

"The marshes are undrained depressions, filled usually with shallow water in which grow plants adapted to such a location, the cat-tail flag being one of the most common. In course of time, these marshes will be filled up by wash from the surrounding land, and so may become valuable for agricultural purposes, even though they may at present be too low to be drained."

This same author gives a table of analyses, which show the average of determinations made on the gravels of the glacial drift:

Analysis of Gravel

Dolomite (Magnesian limestone)	65 per cent
Limestone (Calcareous)	20 per cent
Igneous rocks	7 per cent
Metamorphic rocks	6 per cent
Sandstone and shale	1 per cent
Cherts and quartz	1 per cent
Total	100 per cent

He further states that a correct understanding of the drift in Jay County gives the conception of the drift material as being made up chiefly of till, that is to say,

(1) Of very fine mineral matter, made up partly of clay and partly of finely ground rock mixed in varying proportions with sand of different amounts of fineness,
(2) Of coarser particles (gravel), most of them well rounded, but some subangular and bearing glacial striations, with here and there,
(3) Some boulders in size up to five or six feet in

iameter , all- mixed together in most irregular fashion.

The analysis of gravels of the glacial drift shows them o be 85 per cent limestone and dolomite. Reference has been ade heretofore to the great similarity in chemical composition f waters from the drift and from the bedrock formations. specially is this true in north-central Indiana. The gravels re essentially limestones and dolomites so one should not xpect the mineral constituents dissolved in the ground waters o be radically different from the bedrock waters.

The bedrock formations of Jay County are of Silurian ge. It is believed they are chiefly Huntington dolomite, hough a paucity of outcrops makes final determinations ifficult. Cumings and Shrock (125) have described the quarrying

(125) Cumings, E. R., and Shrock, R. R., The Geology of the ilurian Rocks of Northern Indiana, Publication No. 75, Department f Conservation, State of Indiana. 1928, p 171.

ndustry of this county as follows:

"Limestone has been quarried at only one place in y County, near Portland, and that exposure is no longer o be seen. The quarry, now filled with water, was located ne mile southwest of Portland, in the S. E. ¼ of S. E. ¼ of ection 24, T. 23 N., Range 13 East, on the north bank of he Salamonie River. The stone was below water level in he river, so that when active quarrying ceased the exposure as immediately submerged. The stone, which was of untington age, was burned for lime at the quarry, but now nly the concrete foundations of the kilns and piles of rtially calcined rock indicate the place where the lime urning was carried on."

Generalized Geologic Section for Jay County

aternary:
Recent, -- chiefly alluvium . . . . . .0- 45'
Pleistocene, -- glacial deposits . . . . . 0-451'
lurian:
Huntington, -- dolomite (only formation which outcrops within the county) . . . . . .Not all exposed
dovician:
(No outcrops; determined from well records.)

GROUND WATER

An inventory of the water supply situation in Jay unty shows that a majority of the wells derive their supply om the limestone which underlies the drift. Many wells cure supplies of water from the drift, which is composed of compact sheet of till. The till will average about 100 et in thickness. Rock is rarely struck at less than 50 feet. e well reports a thickness of 451 feet of drift. At Geneva,

in Adams Co. a short distance from the northern Jay Co. line a well boring logged 350 feet of drift. At Bryant, the drift was feet. Leverett in Water-Supply Paper No. 21 gives the followi facts relating to ground water conditions in Jay County:

"At Pennville, in southern Penn Township, on the Salamoni River, rock is struck at about 40 feet in several gas borings.

"At Portland, the county seat, wells are often obtained a 14 to 30 feet in gravel, but more frequently they are drilled into limestone, which is encountered at 30 to 60 feet in the vicinity of this town. A few wells have a depth of 150 feet. waterworks supply is from wells drilled into the limestone. I is thought that the shallow wells are protected from contamina by a bed of clay which overlies the water-bearing gravel.

"Immediately east of Portland wells are obtained in sand tween yellow and blue till at 12 to 20 feet; the blue till is struck at 15 to 30 feet, and extends to the underlying rock at 45 to 50 feet.

"A well in Section 18, Noble Township, 5 miles east of Portland, enters rock at 83 feet; one in Section 17 enters roc at 160 feet; and one in Section 7 enters rock at 57 feet. The are all situated near the south border of the Salamonie morain and are mainly through till.

"Near Bellefontaine, in the east part of the county, well enter rock at 80 to 135 feet, and are mainly through till.

"At Como, 6 miles southwest from Portland, the drift is 80 feet, and at Red Key 73 feet, mainly till at both places.

"At Dunkirk, in the southwestern part of the county, the wells are obtained near the top of the limestone at depths of 65 to 100 feet. The waterworks are supplied from wells of thi class. Shallower wells afford only a small amount of water.

"Along the Mississinewa moraine, in the southern part of county, farmers not infrequently have sunk wells to a depth of 50 or 75 feet or more before obtaining an adequate supply of water. This moraine appears to afford but little water at shallow depths."

Only two outcrops of bedrock have been described from Jay County. One already referred to is located in an abandone quarry about one mile southwest of Portland, near the north ba of the Salamonie River. The other has been described in the e treme northeastern part of the county, at Jay City, in the bed of the Wabash River. It was a limestone stratum.

The Silurian limestones are excellent aquifers. Water percolates downward through the drift and penetrates the pores of the upper portions of the limestone. The contact of the bedrock and drift is a prolific source of water.

Jay County has many natural springs. Some are described as iron and sulphur springs.

A deep well was drilled near Bryant. Water contained in the formation penetrated at 1,570 feet was mineralized. This was probably the St. Peter sandstone. Water was also obtained in the lower-most Ordovician or Upper Cambrian sandstone at a depth of 2,010. This water was reported by the drillers to be a fine potable, fresh water. The writer is inclined to doubt this statement.

Typical Wells in Jay County

ocation	Depth	Quality	Quantity	Formation	Construction
23N-R13E					
Sec. 1	75'	Hard	Good	Limestone	Drilled
Sec. 4	36'	"	"	"	"
Sec. 15	60'	"	"	"	"
Sec. 17	60'	"	"	"	"
Sec. 19	100'	"	"	"	"
Sec. 22	60'	"	"	"	"
Sec. 24	60'	"	"	"	"
Sec. 27	60'	"	"	"	"
Sec. 31	147'	"	"	"	"
Sec. 35	38- 56'	"	"	"	Driven & Drilled
24N-R14E					
Sec. 4	108'	"	"	"	Drilled
Sec. 44	45'	Soft	"	"	"
Sec. 17	110'	Hard	"	"	"
Sec. 20	90'	"	"	"	"
Sec. 27	80'	"	"	"	"
Sec. 32	63'	"	"	"	"
Sec. 32	101'	Medium	"	"	"
Sec. 34	80'	"	"	"	"
Sec. 35	50'	Hard	"	"	"
22N-R13E					
Sec. 6	20'	Medium	Poor	Gravel	Dug
Sec. 6	110'	Hard	Good	Lime	Drilled
Sec. 22	400'	Medium	"	"	"
Sec. 23	193'	Hard	"	"	"
Sec. 23	220'	"	"	"	"
22N-R12E					
Sec. 36	180'	"	"	"	"
22N-R14E					
Sec. 8	70'	"	"	"	"
Sec. 31	128'	"	"	"	"
21N-R12E					
Sec. 2	130'	"	"	"	"
Sec. 33	110'	"	"	"	"
Sec. 22	40'	"	"	Gravel	"
Sec. 34	65'	Medium	"	Lime	"

Portland. -- (population 5,273) The city of Portland owns its public water system. Seven wells, drilled into Silurian limestone furnish the water. Limestone was penetrated at 30 fe Iron and sulphur are present in the water, but are not objectio able. The water level is 14 feet below the curb.

Redkey. -- (population 1,370) The town of Redkey has its own water supply system. Two wells secure water from the lime- stone which is penetrated at 30 to 40 feet. The water level is 28 feet below the curb. The wells are 8 inches in diameter, an were drilled in 1915.

Dunkirk. -- (population 2,583) The city of Dunkirk owns i water supply system. Three wells drilled into limestone produc the supply. The limestone was penetrated at 110 feet. Water stands at 47 feet in the wells. The wells are 6 inches in diam and were drilled in 1906.

Other towns in Jay County are Bryant (population 319); Salamonia (population 180); and Pennville (population 578); non of which has a public water system. A portion of the city of Dunkirk is in Blackford County, the U. S. Census listing 148 citizens of Dunkirk in Blackford County.

JEFFERSON COUNTY

GENERAL FEATURES

Area 364 square miles Population 19,182 (Census of 1930)

Jefferson County is located in the southeastern corner of the ate. Its southern boundary is the Indiana-Kentucky State line. itzerland County is just east of Jefferson. Switzerland County the southeastern "pocket" county.

The maximum altitude of Jefferson County is 925 feet above a level and the minimum is 410, thus giving a total maximum lief of 515 feet. The maximum local relief is 460 feet.

Culbertson has stated in the 40th Annual Report of the Indiana partment of Geology and Natural Resources that the key to the ography and drainage of Jefferson County is the location of the abash-Ohio divide. It divides the county from south to north, ending through Saluda, Hanover, Madison and Monroe Townships. reams east of the divide flow to the Ohio and streams west of divide flow in a roundabout way through the Wabash into the o. It is interesting to note that several streams with their ds within six or seven miles of the Ohio River are required to pt a circuitous route to the Ohio. The surface of the divide fairly flat and to the west the topography is gently rolling. streams have low gradients. On the eastern side of the divide topography is extremely rough and the streams are deeply dis- ted into the upland area. Indian-Kentuck Creek has cut its to the temporary base level of the Ohio River according to bertson, and he states that the crests of the higher hills and ges are from 350 to 450 feet above the level of the Ohio and deeper valleys.

Drainage. -- The western part of Jefferson County lies within White River basin and the eastern and southern portions lie hin the Ohio River basin. The Ohio forms the southern boundary the county. Indian-Kentuck Creek empties into the southeastern ner of the county. It has three branches, Brush Fork, Middle k, and West Fork, which drain the eastern part of the county. fty Creek on which Clifty Falls State Park is located, empties o the Ohio west of Madison. There are other short streams which w into the Ohio.

Graham Fork of the Muscatatuck which belongs to the White er system enters the western part of Jefferson County and ough its main tributary Big Creek and its branches, Kamp k and Middle Fork, drains the northwestern part of the county.

Fourteen Mile Creek drains a portion of the extreme southern of the county and Stuckers Fork drains a small area in the ern portion.

GEOLOGY

The unconsolidated deposits of Jefferson County consist o alluvial materials along the Ohio River, the terrace deposits along the river, flats of the tributary streams and the glacia drift. The present flood plain of the Ohio River or first bottom as it is called locally is the source of ground water in certain areas, however, owing to overflowing during flood stages is not used for permanent supplies. The second bottoms or terrace lands are not so extensive in Jefferson County, though above Brooksburg, in the eastern part of the county, ar present and contain much sand and gravel. The third type of mantle rock is found on the flats of the Wabash-Ohio divide an other high ridges and consists of 20 to 50 feet of glacial dri The county was invaded by the Illinoian glacier and the Ohio River valley and other prominent stream valleys have deposits glacio-fluviatile origin. The city of Madison is built largel on such an alluvio-glacial deposit.

The bedrock formations of Jefferson County consist of strata belonging to the Ordovician, Silurian, and Devonian systems. The Ordovician limestones and shales occupy the eastern one-third of the county. The Silurian rocks outcrop in the central one-third, and the Devonian strata outcrop in the western third. These named distributions are only approxi mate.

Generalized Geologic Section for Jefferson County

Quaternary:	
Recent, -- alluvium.	0- 40
Pleistocene, -- glacial and fluvio-glacial deposits	0- 50
Devonian:	
New Albany, -- shale.	50
Middle Devonian, -- limestone.	50
Silurian: limestones chiefly	90
Ordovician: limestones, shales (Only part of Ordovician exposed).	500

GROUND WATER

The unconsolidated alluvial deposits along the major streams are unfailing sources of ground water and can be obtained at shallow depths. The glacial drift in some areas has been removed, in other areas is of insufficient thickness and in still other areas may be utilized as a source of supply. Frequently the deeply cut streams permit the water to drain from beds which are located topographically higher than the stream. Springs result from this trenching by streams.

At the top of the Richmond (Upper Ordovidian) occurs a hin layer of soft shale. This is overlain by the Brassfield imestone of Silurian age. The shale and limestone contact is spring horizon. Also many springs issue from the top of the rassfield limestone.

Cisterns, shallow wells, springs, and surface supplies from treams and reservoirs furnish water for all purposes in the ounty. The ground waters at depth will be mineralized and nfit for use. None of the outcropping formations of this ounty is considered a real aquifer, though several formations ontain limited supplies of ground water. The dissection of he uplands has permitted waters to drain away.

Water Supplies of Towns in Jefferson County

Madison. -- (population 6,530) The city of Madison has a nicipal water department which obtains the city supply from even wells drilled into the sand and gravels along the Ohio .ver. Bedrock is penetrated at 82- 90 feet. Water stands at) feet in the wells, though this level fluctuates somewhat .th the river stages. At one time Madison secured a water upply from springs and part of its supply from the Ohio River. .stance from the river affords filtration to the present wells ien the water movement is reversed. Ordinarily the movement : toward the river, though the water superintendent calls :tention to the variation in level during the different river ages. This would occur when large rains fed additional pplies to the aquifer, which incidentally might be the same rge rains which raised the Ohio.

Hanover. (population 390); Brooksburg, (population 112); d North Madison, (population 575), have no public water pplies.

JENNINGS COUNTY

GENERAL FEATURES

rea 393 square miles - Population 11,800 (Census of 1930)

Jennings County is located in southeastern Indiana. It is he third county west of the Indiana-Ohio State line and the hird county north of the Indiana-Kentucky State line. At the earest point to the Ohio River, Jefferson County lies between ennings and the Ohio. Vernon is the county seat.

The maximum altitude in Jennings County is 885 feet above ea level, the minimum is 535 feet, thus giving a total maximum elief of 350 feet. The maximum local relief is 165 feet.

Thr general expression of the topography in the county is olling to rough. On the uplands, far from the streams, there s some flat country, and some gently rolling, however, the treams have maturely dissected considerable portions. The opography is a direct expression of the geological conditions. any streams are entrenched on the gently inclined plain which s a part of the Muscatatuck Regional Slope. The southwestern ortion of the county is a part of the Scottsburg Lowland.

Drainage. -- All of Jennings County lies within the White iver basin. Sand Creek which is a branch of the East Fork of hite River together with its small tributaries collects the urface waters in the northwestern part of the county. The ortheastern, central and western portions of the county are ained by the Vernon Fork of the Muscatatuck River and its ributaries. On the east the important tributaries are Sugar reek, Brush Creek, Otter Creek and Long Creek.

Big Graham Creek drains the southeastern portion of the unty. Its principal branch is Little Graham which joins it the eastern part of the county. The Muscatatuck River forms e boundary for the southwestern part of the county and a few all tributaries drain this area.

GEOLOGY

The unconsolidated deposits of Jennings County consist of luvial and glacial deposits. The alluvial deposits are along e major streams and the glacial deposits mantle the higher ats and divides. During Wisconsin glacial times the scatatuck and other streams were ponded which permitted eater accumulations of fluvio-glacial deposits in the flood lains. These deposits are an excellent source of ground water.

The rocks which underlie the drift and which are exposed many places consist of strata of Silurian and Devonian age. A narrow belt along the eastern part of the county consists of Silurian rocks. The remainder of the county is underlain by Devonian strata. A very few outcrops of Ordovician in creek beds occur in eastern part of the county.

The New Albany shale of the Devonian occupies over fifty per cent of the surface area of the county. It is largely responsible for the physiographic expression.

Generalized Geologic Section for Jennings County

Quaternary:	
Recent, -- alluvium.	0- 30'
Pleistocene, -- Illinoian glacial drift.	0- 70'
Devonian:	
New Albany, -- shale	100'
Middle Devonian, -- limestone.	50'
Silurian:	90'
Ordovician: (Few exposures in eastern part of county, in creek beds)	25'

GROUND WATER

Springs occur frequently in Jennings County on hillsides or valleys at points of contact of porous layers with impervio beds. The recent alluvial deposits along the streams and the glacial drift are sources of ground water.

Bedrock formations of the county carry water in various localities. A well drilled 66 feet at North Vernon penetrated Silurian limestone and was an excellent producer. This same well is reported to have penetrated the St. Peter sandstone at 1400 feet and salt water rose to within 200 feet of the surfac or 500 feet above sea level. Many areas in the county have difficulty in obtaining adequate water supplies. Especially i this true in that part of the county underlain by the Devonian shale. Many wells drilled in this area are only seep wells, a cisterns must be used by the citizens for domestic supplies.

Water Supplies of Towns in Jennings County

North Vernon. -- (population 2,989) The city of North Vernon owns its water system. The supply is taken from the Muscatatuck River. Wells are obtained at depths of 12 to 35 feet.

Vernon. -- (population 410) The town of Vernon has no public water supply system.

J O H N S O N C O U N T Y

GENERAL FEATURES

Area 322 square miles Population 21,706 (Census of 1930)

Johnson County is located immediately south of the geographic center of the State, or in the south-central part of the state.

The maximum altitude of the county is 930 feet above sea level and the minimum altitude is 610 feet above sea level, thus giving a total maximum relief of 320 feet. The maximum local relief is 225 feet.

The surface of Johnson County is made up of two distinct types of topographic forms. These two features are the level to gently undulating plains and the areas which are hilly and much dissected. The greater portion of the surface of the county is plane, however, there are morainic ridges which traverse the county. One morainic ridge in the northern part of the county extends a little south of east from Greenwood to within two miles of the eastern boundary of the county. The relief of this ridge is only 25 to 50 feet above the bordering plain. A noticeable feature is the number of granitic boulders at the surface, some of which at one time measured 20 feet in diameter.

Another morainic belt extends northwest-southeast across the county, passing west and south of the city of Franklin. This moraine has a width of two to five miles, however, it varies greatly in height and intensity. A small outlier of this moraine is found east of Franklin.

A third morainic belt occurs near the southern border of the county, which is low and inconspicuous in the eastern part but is sharp and prominent in the southwestern part of the county. It has a relief of 75 feet or more in places. It is probable that this southern moraine is a remnant of the Illinoian ice invasion and that the two previously described moraines were from the more recent or Wisconsin glaciation.

The southernmost morainic belt of Johnson County marks the outermost border of the Wisconsin Drift sheet in this area, so Johnson County was covered by the two recognized ice invasions.

Drainage. -- All of Johnson County lies within the White River drainage basin. The West Fork of White River crosses the northwestern corner of the county. The western part of the county with the exception of the southwestern portion is

drained by tributaries of the latter stream. The principal branches are Pleasant Run, Honey, Pen, Bluff and Crooked Creeks North Fork of Stotts, Middle Fork of Stotts, Coots Creek and South Fork of Stotts, named in order from north to south.

The southwestern corner of the county is drained by branches of Indian Creek. The south-central portion is drained by Nineveh Creek and its branches. The drainage of the eastern part of Johnson County is accomplished by Sugar Creek which flows southward along the eastern border of the county. Leatherwood Creek and its tributary Flat Branch flow southward into Sugar Creek. Blue River crosses the very southeastern corner of the county.

GEOLOGY

The unconsolidated deposits of Quaternary age consist of Recent alluvial deposits and Pleistocene glacial deposits. The alluvial deposits are along the major streams and the glacial deposits mantle the interstream areas. Much of the gravel and sand has been washed out from deposits left by the retreat of the glaciers. The drift is very thick throughout the entire area of Johnson County. In some areas, notably in the southwestern part of the county, the bedrock is found at shallow depths. This has an explanation based on geologic facts. The southwestern part of the county is the area of outcrop of Mississippian rocks, provided the surface mantle of drift did not exist. It is true that the Borden series of rocks is bordered on the east by the "Knobstone Escarpment" farther to the south and without doubt this same scarp would be prominent in Johnson County had not glaciation been so important. Also the area in Johnson County over which the thick deposits of drift exist is the normal outcrop area of the Devonian black shales which are soft and non-resistant. It is quite probable that the glacier had a scouring action on this shale and scooped it out freely, and left drift to the level of the bordering "Borden" rim on the southwest.

The glacial drift consists largely of a compact till, though the morainal areas contain much gravel and wells penetrate sands and gravels, especially in the lower portions of the drift. A well at Franklin College in Franklin had the following section:

Sand and gravel	18'
Blue till	40'
Fine sand	3'
Blue till	50'
Gravel	3'
Total	114'

Leverett also gives the following section of a gas-well drilled at Franklin, 1140 feet in depth.

Till, yellow and blue.	45'
Sand	20'
Blue till, with thin sand and gravel beds.	105'
Total	170'

The bedrock formations of Johnson County contain strata of Devonian and Mississippian age. These bedrock formations were eroded before the deposition of the glacial drift which attains, a thickness of as much as 200 feet in the county, though in some places it is only a few feet thick.

The Devonian strata underlie the northeastern three-fourths of the county and the Mississippian rocks underlie the southwestern quarter of the county.

Generalized Geologic Section for Johnson County

Quaternary:	
Recent, -- sands, clays and gravels.	0- 40'
Pleistocene, -- clays, sands and gravels . . .	0-170'
Mississippian:	
Borden, -- shales and siltstones	0-400'
Devonian: limestones and shales	300'
Silurian: limestones (Not exposed)	300'

GROUND WATER

Springs are fairly numerous in Johnson County. They are formed at points where outcropping beds of porous strata occur along the banks of small streams or along valley walls. Most of the ground water used in Johnson County comes from the glacial drift. At Franklin and other towns in the county the water is pumped from wells in the drift. A deeper well at Franklin produced water from a depth of 450 feet. This well flowed. At Greenwood a well was drilled in 1894 to a depth of 1725 feet. The bottom of the hole was reported to be 5 feet below the top of the St. Peter sandstone. The water from the St. Peter rose to within 325 feet of the surface. The water had a hydrogen sulphide odor, a saline taste and was dark in color. Other mineral springs and mineral wells have been described in Section 7, Township 11 North, Range 4 East. The springs were reported to issue from the point of contact of the boulder clay and the bedrock. Blatchley in the report of the Indiana Department of Geology and Natural Resources for 1901 described a spring some seven miles south of Franklin as follows: "A spring emerges from the black Devonian shale on the south side of Sugar Creek, about midway between the State road and the railway. It flows about 75 gallons an hour, of a

clear, cold water, which tastes strongly of iron oxide. The spring has built up a large mound of ferrugionous, carbonaceou material below its original outlet, and flows over the top of this mound, the size of which is slowly increasing by deposits from the water. No analysis has been made. The water has quite a large local use."

A well drilled in Section 8, Township 12 North, Range 4 East logged water at 462 feet and at 1812 feet. The water horizon at 462 is probably Silurian limestone and at 1812 feet was in some Ordovician formation.

Water Supplies of Towns in Johnson County

Franklin. -- (population 5,682) The city of Franklin is furnished water by the Interstate Public Service Company, a private corporation. The water is obtained from three wells, which penetrate the glacial drift.160 feet and water is found at base of drift. Water stands at 35 feet from the surface. Private wells in Franklin vary from 16 to 70 feet in depth and many of the drift wells that are shallow bear water which has a slight sulphur taste.

Edinburg. -- (population 2,209)) The town of Edinburg receives a supply of water from one well which is 12 inches i diameter and produces from the gravels. Water stands at 15 feet in wells in the community. This Edinburg well was drille in January 1929 and thus far has proven an excellent well. Th town owns the water system.

Greenwood. -- (population 2,377) The town of Greenwood is supplied water by a private corporation, which obtains wate from a dug well and from tubular wells. The water is from the glacial drift.

Whiteland. -- (population 419) The town of Whiteland has no public water supply system.

Bargersville. -- (population 282) The town of Bargersvil does not have a town supply of water, however, many private wells secure an abundance of good water from 40 to 100 feet into the drift.

KNOX COUNTY

GENERAL FEATURES

ea 510 square miles Population 43,813 (Census of 1930)

Knox County is situated in southwestern Indiana. It is the ird county north of the Indiana-Kentucky State line. Its stern boundary is the Wabash River, which is the Indiana-linois State boundary line. Vincennes is the county seat.

The highest altitude in the county is 610 feet above sea vel, the minimum is 376 feet, thus giving a total maximum lief of 234 feet. The maximum local relief is 90 feet.

Knox County has a few distinctions which may be mentioned. is the oldest county in the State. The original Knox County s established in 1790. It possesses more river boundary lines than y county in Indiana; the eastern, southern, and western ndaries are rivers. It is the eighth largest county in the ate and about one-fourth of its area is valley land.

Most of the upland areas in Knox County are undulating to lling, and very rugged surface features are absent with the ception of the immediate stream bluffs. It is also a fact at very little flat land is found, though the relief is not eat. The valley flats along the streams make up about 25 cent of the area of the county. Knox County is contained in e Wabash Lowland physiographic unit. The surface is underlain non-resistant rocks. The proximity of the Wabash to the area plains in a large measure the low relief of the county.

Drainage.--Three major streams control the drainage of Knox nty. The Wabash River forms the western boundary of the nty, the West Fork of White River forms the eastern boundary, White River is the southern boundary. Busseron Creek crosses northwestern corner of the county, flowing southwestward to Wabash. Maria Creek and its tributary enter the county from north and the former flows southwestward to the Wabash. pps Creek enters the Wabash near Vincennes. River Deschee ins the southwestern part of the county to White River. It been diverted from its original course by construction of ss Ditch.

GEOLOGY

The unconsolidated deposits of the county consist of avium along the present streams and glacial deposits. All the county is mantled with Pleistocene deposits. In the leys the thickness runs up to 100 feet or more. On the

uplands the drift will not exceed 50 feet, in many places is not more than 5 or 10 feet, and is removed in certain areas.

The recent deposits of the county were formed by the reworking of the surface materials by surface waters and other weathering agencies. Loess, drift, and residual materials have been carried down the slopes during high waters, resulting in deposition in the valley flats and second bottoms. Small areas of swamp in the county are being filled with muck, silt, and vegetable remains.

Large areas in the Wabash bottoms are covered with dune sands. Loess also mantles large areas in the county.

The indurated strata of Knox County are all of Pennsylvanian age. They consist of sandstones, shales, thin limestone clay, coals, and underclays. The eastern margin of the county is within the outcrop belt of the Allegheny series, and the remainder is underlain by Post-Allegheny rocks. The surface was eroded before the deposition of the glacial drift. The latter varies in thickness from a few feet to more than 100 feet.

Generalized Geologic Section for Knox County

Quaternary:
Recent, -- alluvium, dunes. . . . . 0- 40'
Pleistocene, -- glacial deposits. . . . . 0- 150'
Pennsylvanian: (Determined from well records) . . 1080'
Mississippian: (Not exposed)

GROUND WATER AND OTHER SOURCES OF WATER SUPPLY

Large supplies of surface water may be obtained in Knox County from the Wabash, the West Fork of White River, and from White River. Surface waters may be obtained from lakes and ponds on the flood plains of these rivers. The important bodies of water of this type are Broadies Lake in Busseron Township; Marie Pond in Busseron and Washington Townships; Horse Shoe Bend in Vincennes Township; Watsons Pond in Decker Township; Swans Pond in Johnson Township; and Long Pond in Palmyra, Steen, and Harrison Townships.

Springs exist in some parts of the county along the river bluffs. Waters may be impounded on the water-sheds and in the streams.

Ground waters may be obtained in all parts of the county from several geological horizons.

The Recent, Pleistocene, Pennsylvanian, and Mississippian formations contain ground water. The first two mentioned are the source of most water used for domestic purposes in Knox County.

The Baltimore and Ohio Railroad Company has kindly urnished log and information on a well drilled by that company t Vincennes, Indiana. The well is located 100 feet south of he Wabash River bridge owned by that company and is within 00 feet of the river bank. The log is as follows:

Fill and sand.	0- 20'
Sand	20- 40'
Clay	40- 55'
Sandy clay	55- 69'
Clay	69- 70'
Soft sandstone	70- 80'
Blue clay	80-100'
Soft open sandrock	100-158'
Blue clay.	158-160'
Total	160'

This well was drilled in 1930-31 and a test on February 15, 931, developed that static level was 24 feet to water and elivery of 150 g.p.m. out of well dropped the water rapidly to 50 feet. This did not meet the demands of the railway company, nd it was necessary to augment this supply with water from he Wabash River. This admixture is now being used at the rate f 100,000 gallons per 24 hours.

The chemical analysis of water from original well on ugust 23, 1930, was as follows in grains per gallon:

Total Solids	24.19
Chlorine	0.44
SO-3	1.87
Alkalinity	19.31
Hardness	13.00
Turbidity	Slightly cloudy

The analysis of the Admixture on July 15, 1932, was as llows.

Total Solids	27.87
Chlorine	0.70
SO-3	4.20
Alkalinity	14.69
Hardness	17.70
Turbidity	3.73

An analysis of a well at the Vincennes Canning Company, cated one-half mile east of the Union Depot and obtained rough the kindness of the B. & O. R. R. Co., is as follows:

(The analysis is dated 1916.)

Total Solids	24.14
Chlorine	0.23
SO-3	0.10
Alkalinity	21.57
Hardness	19.24
Turbidity	Clear

No records as to depth, formations, etc., were available on the above well.

An analysis of a well 125 feet in depth at Vincennes, drilled for the Hack Simmons Brewery, dated June 28, 1915, is as follows:

Total Solids	21.86
Chlorine	0.26
SO-3	0.64
Alkalinity	20.70
Hardness	18.07
Turbidity	Very slight.

Logan (126) has published a number of well records from

(126) Logan, W. N. The Sub-Surface Strata of Indiana Publication No. 108, Department of Conservation, State of Indiana, 1931. pp. 392-416.

Knox County. Many of these logs show water sands in the upper portions of the Pennsylvanian. In general the chances of obtaining potable water supplies are good; however, mineralized waters associated with the coals, clays, and shales might make drilling a well a total loss. Individuals can not afford the expense of drilling and lifting water several hundred feet, so the deeper strata are unlikely to be utilized. The deeper strata are likely to contain mineralized waters.

Water Supplies of Towns in Knox County

Vincennes. -- (population 17,564) The city of Vincennes is furnished water by the Vincennes Water Supply Company, a private organization. The water is obtained from the Wabash River and thoroughly treated.

Bicknell. -- (population 5,212) The city of Bicknell owns its water system. The supply is obtained from 13 wells drilled into gravels and sands. Bedrock is reported at 60 feet. Water stands at 20 feet in the wells.

Oaktown. -- (population 771); Monroe City (population 544); Decker (population 468); and Wheatland (population 806) are incorporated towns in Knox County which do not maintain public water supply systems. Private wells are in use in the various towns.

K O S C I U S K O C O U N T Y

GENERAL FEATURES

Area 541 square miles Population 27,488 (Census of 1930)

Kosciusko County is located in northeastern Indiana. It is the second county south of the Indiana-Michigan State line and the third county west of the Indiana-Ohio State line.

The maximum altitude in the county is 950 feet above sea level, and the minimum is 770 feet, thus giving a total maximum relief of 180 feet. The maximum local relief is 90 feet.

Capps in Water-Supply Paper #254 of the U. S. Geological Survey writes:

> "Kosciusko County has a great many lakes and ponds-- more than any other county in this region. These range in size from Turkey Lake, which has an area of about six square miles and is the largest lake in the State, to small ponds only a fraction of a square mile in area. All the lakes occupy depressions in the morainic material and many of them have been partly filled by silt and by vegetable growths and are marshy."

Kosciusko County presents a typical glaciated topography. The eastern part of the county is morainal and about fifty per cent of the county consists of rolling hills and hummocks and intervening depressions occupied by lakes. The northwestern portion is lower topographically than the morainal belt to the east and south; however, it serves as the drainage divide for Wabash-Lake Michigan waters. The present topography is entirely a result of the form of the glacial deposits and to the subsequent erosion of their surface.

Drainage. -- A large part of the drainage of Kosciusko County is controlled by the Tippecanoe River and its branches. This stream flows through the central part of the county. Eel River crosses the southeastern part of the county and sends out several short branches into the southeastern portion. Silver Creek, one of its branches, heads in Silver Lake and flows south. Clear Creek lies east of Silver Lake and flows south.

Yellow River heads in Wawasee Lake and flows northwestward through the county. In the southwestern part of the county Yellow Creek heads in Yellow Creek Lake and flows northwest to discharge into the Tippecanoe River. Another small stream heading in Rock Lake in the southwestern part of the county flows northwestward into the Tippecanoe River.

There are a large number of important lakes in Kosciusko County. The largest is Wawasee or Turkey Lake in Turkey Creek Township. Others are Syracuse, Pappakeechie, Grindle, and Speark Lakes. Tippecanoe Township contains James Lake, Webster Lake, Shoe Lake, Irish Lake, Herron Lake, Mable Lake, Seeris Lake, Hammon Lake, Tippecanoe Lake, the Barbee lakes, and Boydston Lake. Wayne Township contains Pike Lake and Eagle Lake Plain Township has Little Eagle Lake. In Seward Township are Mud Lake, Yellow Lake, and Rock Lake. Palestine Lake is in Harrison Township and Hoffman Lake in Prairie Township.

GEOLOGY

The unconsolidated deposits of Kosciusko County consist of valley alluvium and glacial drift. The largest area of alluvium is found along the Elkhart River in the north part of the county Narrow flood plains occur also along the Tippecanoe River and Eel River and occasionally small areas of alluvium occur along some of the smaller streams; however, they are not important sources of water supply.

Capps describes some glacial outwash plains as follows:

> "The outwash plain northwest of Warsaw has considerable gravel and sand mixed with clayey materials and is alluvial in its nature. At Leesburg and at Menoquet the outwash deposits are thick enough to furnish important water supplies to driven wells of shallow depth. Farther northwest the outwash becomes thinner and most wells pass through it into the underlying till for their water."

The glacial drift of the county consists of till plain and moraine. Practically all of the northwestern portion of the county is occupied by ground moraine or till plain which consists of gravel plains, clay areas, and marshes. The remainder of the county is covered with morainal drift; however, the moraines were dumped by the glaciers on the till plain, so a well drilled through the morainal material will reveal the ground moraine much the same as in the northwestern part of the county. The history of the moraines in Kosciusko County is a bit complicated due to the different sources from which the lobes of the glaciers were derived and each lobe had an independent history. Kosciusko County is considered to be interlobatal territory with the morainal remnants that exist today, being materials discarded by the Saginaw and Erie lobes of the Wisconsin glaciation. Dr. Malott regards the main morai in this county, known and described by him as the Packerton moraine, to be the eastern remnant or limb of the Maxinkuckee moraine, which is so prominent in Marshall, Fulton, and St. Joseph counties to the west and north.

A well drilled at Syracuse penetrated 278 feet of glacial materials; one drilled at Warsaw showed 248 feet of drift, and it is believed that the drift will average 200 feet in thickness throughout the county.

Bedrock outcrops at no location in the county and very few wells have penetrated the bedrock. Inquiry of 60 well owners scattered throughout the county failed to show a single well producing water from the rock underlying the drift, and all without exception reported their water supply to be coming from the gravels of the drift.

It is believed that the bedrock formations of Kosciusko County are chiefly of Devonian age. A small area in the southern part of the county may have Silurian strata underlying the glacial drift and a small area in the northern part of the county may have rocks of Mississippian age under the drift. The well drilled at Syracuse on the property of the Sandusky Cement Company showed 63 feet of New Albany (Devonian) shale underlying the drift. A well drilled several years ago at Warsaw to a total depth of 1437 feet was logged as follows:

Drift	248'
Limestone	652'
Shale.	487'
Trenton Ls	50'
Total . .	1437'

Generalized Geologic Section for Kosciusko County

Quaternary:	
Recent. -- chiefly alluvium.	0- 20'
Pleistocene.	150-250'
Mississippian: (Not exposed)	
Devonian: (Not exposed)	

GROUND WATER AND OTHER SOURCES OF WATER SUPPLY

Surface waters may be obtained from streams, lakes, and springs in Kosciusko County. Additional supplies may be obtained by the impounding of water in streams and in reservoirs built on the water-sheds of the streams.

This county has a large number of lakes and at one time had considerable marsh land. This indicates that the water-table has stood at and near the surface over a large portion of the county. The present lakes are fed by rainfall and by ground water. In geologically favored localities the wells still flow. Many flowing wells have been located along the margins of the various lakes and as the wells were relatively shallow it lends additional proof to the statement that the lakes are fed by ground water.

It is believed that the strata representing the various systems of rocks which underlie the surface of Kosciusko County will bear ground water. The unconsolidated materials are the b aquifers, especially where gravels are abundant. The Devonian black shale which is believed to underlie a large portion of th county immediately below the glacial drift is not an aquifer; however, the limestones and sandstones comprising the remainder of the Devonian system are usually water-bearing. The Silurian limestones also bear excellent water in various localities. Th Ordovician strata contain waters which are mineralized and unfi for consumption

The upper surface of the Trenton limestone lies at an elevation of approximately 400 feet below sea level in the sout western corner of Kosciusko County, while in the northeastern part of the county it is 900 feet below sea level. It is believed that the strata immediately underlying the drift dip to the northeastward.

Water Supplies of Towns in Kosciusko County

Claypool. -- (population 382) The town of Claypool owns i public water system. One well drilled into the gravels of the drift is the source of the water. Water is reported to stand a 10 to 15 feet in wells in the town, and springs were plentiful 20 to 30 years ago. Bedrock was reported at 100 feet; however, no logs or records were received to substantiate this statement

Mentone. -- (population 704) The town of Mentone owns its public water system. Two wells drilled into glacial gravels ar the source of water. One well 8 inches in diameter was drilled in 1912; the other, 10 inches in diameter, was drilled in 1925. Water stands at 10 to 20 feet in the area.

Silver Lake. -- (population 442) The town of Silver Lake owns its water system. One well drilled to 130 feet yields the supply. It is an 8-inch well drilled in 1925. Water stands from 15 to 50 feet in wells in the community.

Syracuse. -- (population 1,190) The town of Syracuse owns its water supply system. The water is obtained from tubular wells. The town is located on the west shore of Lake Syracuse. Water is reported to stand at a depth of 6 feet in wells in the town, thus indicating that the water table is at or near lake level. Two wells, 40 and 26 inches in diameter, drilled in 192 furnish the water supply to the town. Springs are abundant in this locality.

Pierceton. -- (population 878) The town of Pierceton owns its water system. Two wells furnish the supply from the gravels of the glacial drift. One well is 6 inches in diameter and was drilled in 1900; the other is 10 inches in diameter and drilled in 1925. Springs were abundant in this region until artificial drainage was used so very much.

Warsaw. -- (population 5,730) The water supply system of the city of Warsaw is privately owned. Water is procured from Center Lake.

Milford. -- (population 869) The town of Milford owns its water supply system. The town is located on an outwash gravel plain in the north-central part of the county. Four wells produce water from the gravels and till. Water stands at 11 to 15 feet in the wells. Many private wells penetrate the drift 40 to 75 feet.

Sidney. -- (population 182); Leesburg (population 371); and Winona Lake (population 454) are other towns in Kosciusko County. They do not maintain public water supply systems. The drift affords the supply of ground water to private wells. The many lakes in this region indicate the water-table is near the surface. With proper precautions excellent ground water supplies are readily obtained.

MINERAL ANALYSES OF WATERS FROM KOSCIUSKO COUNTY

(Parts per million)

Location	Geological conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
Burket	Gravel		.6		118					240	41	55	2.5	.002	2	566
Claypool	Gravel		1.2		108	28				293	32	9	.1		2	370
EtnaGreen	Gravel		1.6		94	26				241	64	26	4	.001	9	400
Etna Green	Gravel		1.6		83	27				302	10.7	1	.2	.001	42	342
Leesburg	Gravel		.01		112	26				304	99	31	6		4	532
Mentone	Gravel		.2		64	20				243	64	11	.4		4	534
Milford	Gravel		.01		68	23				224	160	15	2		2	312
Pierceton	Gravel		.15		53	30				294	1.2	1	.4	.001	19	344
Sevastopol	Gravel		.10		106	26				294	7	9			4	322
Sidney	Gravel		1.2									34	.05	.001	42	464
Sidney	Gravel		1.4		66	30				303	93	1	.3	.001	13	416
Silverlake	Gravel		.04		138	36				378	52	76	8	.001	9	696
Syracuse			.6		86	35				342	140	17	.1		4	404
Winona Lake			.3		87	25				293	9	2	.3	.001	9	282
Winona Lake		13	.7	48	84	24	4.3	.45		323	48	2.9	.44			339
Winona Lake		9.9	4.1		88	8.1	9.5		109		66	14				321
Winona Lake	Sand	27	1.06		62	26	25			339	8.6	.2	1.2			304
Winona Lake	Gravel	27	1.3		62	26	23			345	4.8	.2	1.5			305

( ) Water-Supply Paper 254, 0. 165.

LAGRANGE COUNTY

GENERAL FEATURES

Area 387 square miles Population 13,780 (Census of 1930)

Lagrange County is in northeastern Indiana. Its northern boundary is the Indiana-Michigan State line. It is the second county west of the Indiana-Ohio State line. Lagrange is the county seat.

The maximum altitude of the county is 1.027 feet above sea level, the minimum is 830, thus giving a total maximum relief of 197 feet. The maximum local relief is about 100 feet. The county is a part of the Northern Moraine and Lake Section of the State. Over fifty per cent of the surface of the county is morainal material. Lakes are frequent. The remainder of the surface is till plain.

Drainage. -- The drainage of a larger part of the county is controlled by Pigeon River and its tributaries. This stream enters the county from Steuben County, a little north of the center of the eastern boundary and flows in a northwesterly direction to leave the county and the State about five miles east of the northwest corner of Lagrange County. Turkey Creek, Fly Creek, and Buck Creek are southern tributaries of Pigeon River within the county. Little Elkhart River drains the west central portion of the county. Its principal tributary is State Ditch which flows in a northwesterly direction. North Creek rises in a group of lakes in the southern part of the county and flows southward.

GEOLOGY

Lagrange County is mantled with a great thickness of glacial drift, which will average 200 feet in thickness. The drift is composed of till, gravels, and sand.

Alluvial deposits along the streams are of major importance from the standpoint of ground water. Outwash gravels which are a product of glaciation are excellent sources of ground water.

There are no outcrops of bedrock in this county. From a study of well records, it is believed that the entire county is underlain by strata of Mississippian (Borden) age. Less than a dozen wells in the county have penetrated the bedrock, so little is known about the strata.

Generalized Geologic Section for Lagrange County

Quaternary:
- Recent, -- chiefly alluvium . . . . . 0-50'
- Pleistocene, -- glacial deposits . . . . . 150-400'

Mississippian: (No outcrops)
- Borden, -- (Determined from well logs) . . . . . 500'?

A deep well has been drilled near Howe, which is believed to have penetrated some of the deeply buried Ordovician formations. Logan has published this log on page 415 of Publication No. 108, Department of Conservation, State of Indiana, as follows:

Gravel and quicksand (10 inch pipe)	309 feet
Gray shale (Mississippian)	500
Brown and black shale (Devonian)	720
Brown, hard limestone (Devonian)	840
Nice oil sand, some gas (Pendleton Ss.)	845
Brown, hard limestone (Silurian)	1140
Gray, hard limestone	1305
White, hard limestone	1585
Blue shale	1600
Blue shale	1630
Gray limestone	1645
Blue shale	1660
Gray limestone	1670
Shale	1700
Lime shell	1710
Shale	1740
Gray limestone	1750
Shale	1770
Blue limestone	1785
Blue shale	1835
Lime shell	1845
Blue shale	1910
Shell	1915
Brown shale	2200
Blue shale	2225
Cap rock	2233
Good oil sand with show of oil	2235
Hard sandstone	2270
Brown limestone	2275
Gray limestone	2280
Brown limestone	2290
Fine gray dolomitic sand	2800
Coarser calcareous broan sand with pyrite and magnetite	2840

It is believed that all of the bedrock formations which normally bear ground water, would carry waters unfit for consumption. In Lagrange County these aquifers are deeply buried and water has no chance to escape, hence becomes stagnant and unfit for use.

GROUND WATER

Twenty-four residents of Lagrange County were questioned during this investigation about the source of their ground water supplies. All of them reported the source was gravel or the glacial drift which was the aquifer. The wells varied in depth from five to 125 feet. They were widely distributed throughout the county. It is believed that a representative selection of wells was made.

The gravel plain traversed by Pigeon River is a prolific source of water. This plain has a width of two to six

miles and crosses the county for 20 miles or more. Other gravel areas are the Haw patch near the southern boundary of the county and still another borders the Little Elkhart River in the western part of the county.

Leverett has published additional information on Lagrange County as follows:

"On the strong morainic belt in the northwest part of the county the sharpest knolls are usually made up of gravel and sand, but those of gentler contour often contain till. The wells vary greatly in depth, some being but 15 or 20 feet, while others are 50 to 75 or more. On the overwash gravel plain south of this moriane wells are obtained in gravel at about 20 feet.

"In a feeble moraine on the north side of Little Elkhart River, in the western part of the county the wells are usually about 30 feet in depth; after penetrating 10 to 20 feet of till they enter sand. South of Little Elkhart River the wells are mainly through till. The average depth is 30 to 40 feet, but occasional wells reach 60 feet.

"In the gravel plain along Little Elkhart River the wells are usually but 12 to 20 feet in depth, entirely through gravel and sand.

"At Lagrange wells are obtained at about 100 feet at the city waterworks, but private wells seldom exceed 40 feet. The detailed record of four of the waterworks wells, published by Dr. Dryer in the 18th Annual Report, Indiana Geological Survey, pp. 80-81, show alternations of sand and gravel with till, in which the thickest beds are but 20 to 25 feet. In well No. 1, 92 feet in depth, the gravel beds amount to 32 feet, the thickest bed being 12 feet in the upper part of the section. In well No. 2, 102 feet in depth, the gravel and sand amount to 47 feet, of which 17 feet occur at the bottom of the well. In well No. 3, 98 feet in depth, the sand and gravel amount to 34 feet. In well No. 4, 111 feet in depth, the sand and gravel amount to 33 feet. These wells are within the area of an ordinary town lot, and yet Dr. Dryer reports that the majority of strata can not be correlated in any two of them. In well No. 1 there are 6 beds of gravel; in wells Nos. 2-4, but 5 beds of sand and gravel.

" A well near the jail at Lagrange penetrates --

1. Yellow	till	8 feet
2. Dry sand	. . . . .	30 "
3. Gravel with water	. . . . .	2 "
	Total	40 "

A prospect boring for artesian water at the jail penetrated according to Leverett the following section:

"Yellow till . . . . . 15 feet
Blue till, with thin beds of sand . 30
A brown mold or sil 4
Cemented gravel 5
Loose gravel with water 8
Blue till 45
Cemented gravel 8
Dry sand and gravel 70
Total . . . . . 205 "

Also Leverett gives the following information of a well drilled for Dr. Drake, one-half mile north of Valentine.

"Sandy yellow till . . . . . 10 feet
Blue till 41
Gravel with inflamable gas. 3
Blue clay 46
Black muck with leaves and gas . . 6
Soft blue clay 24
Water-bearing sand, coarse at bottom 10
Total. . . . . 140 "

"A well in the southeast part of the county, one-half mile east of South Milford, penetrates --

"Sandy yellow till . . . . . 20 feet
Blue till . . . . . 49 "
Very fine sand . . . . . 20 "
89 "

"A similar fine sand was found in the well at Joseph Ryer's, 4 miles north of Wolcottville, at 30 to 108 feet from the surface.

"A well in the west part of Milford Township, 3 miles north of the county line, 97 feet in depth, is largely through sand, gravel, and cobble.

"In the vicinity of Pretty Lake and Long Lake, in Milford Township, in the southeast part of the county, there are gravel plains on which wells obtained water at 30 or 40 feet without reaching the bottom of the gravel. On bordering districts wells usually penetrate 25 to 40 feet of till before reaching a water-bearing gravel.

" Dr. Dryer reports the occurrence of coal in the drift beds in the southwest part of the county at depths of 76 feet in two neighboring wells under which beds of water-bearing gravel occur. A boring on a neighboring farm is thought to strike shale at 150 feet."

The glacial drift and associated gravel plains will continue to serve Lagrange County citizens as aquifers. The deep well water prospects of this county are very unpromising. The first few hundred feet below the drift

are likely to be impervious and at greater depths the water will be unfit for use.

Water Supplies of Towns in Lagrange County

Lagrange. -- (population 1.640) The town of Lagrange owns its water system. Tubular wells which penetrate the drift about 100 feet furnish the supply. Attention has already been directed to the lense-like character of the sand and gravel beds in this vicinity. There is considerable variation from well to well.

Wolcottville.-- (population 646) The town of Wolcottville owns its water system. Three wells produce water from glacial gravels. The water level is given as 98 feet. Natural springs are abundant in this area. The waters in this area are artesian. The town of Wolcottville is divided as follows: Noble County 308, Lagrange County 338.

Topeka. -- (population 489) The town of Topeka owns its water supply. Four wells producing from gravels furnish the supply. The water level is 28 feet, depth to bedrock unknown.

Shipshewana. -- (population 262) The town of Shipshewana maintains no public water supply system.

Typical Wells of Lagrange County

Location	Depth	Quality	Quantity	Formation	Construct
T38N-R11E					
Sec. 26	30-40	Hard	Good	Gravel	Driven
Sec. 27	34-40	"	"	"	"
Sec. 29	75-100	"	"	"	Drilled
Sec. 30	40-45	"	"	"	Driven
T38N-R10E					
Sec. 30.	28-40	"	"	"	"
T37N-R10E					
Sec. 19	125	"	"	"	Drilled
Sec. 22	40-60	"	"	"	Driven
Sec. 35	14-27	"	"	"	"
T36N-R10E					
Sec. 14	30-100	"	"	"	Driven Drilled
Sec. 33	120	"	"	"	Drilled
T37N-R11E					
Sec. 19	5-102	"	"	"	"
Sec. 22	40	"	"	"	Driven
Sec. 22	35	"	"	"	Drilled
Sec. 29	35-40	"	"	"	"
T36N-R8E					
Sec. 36	125	"	"	"	"
T38N-R8E					
Sec. 25	20	"	"	"	Driven
T38N-R9E					
Sec. 28	20-76	"	"	"	"
T37N-R8E					
Sec. 11	20-65	"	"	"	"
Sec. 23	20-25	"	"	"	"
T37N-R9E					
Sec. 20	65	"	"	"	"
Sec. 22	65-70	"	"	"	"
T36N-R11E					
Sec. 5	65	"	"	"	Drilled
T36N-R9E					
Sec. 13	20-30	"	"	"	Driven
Sec. 14	75-90	"	"	"	Drilled

L A K E C O U N T Y

GENERAL FEATURES

Area 492 square miles Population 261,310

Lake County is the very northwestern corner county in the State, bordering Lake Michigan and the state of Illinois.

The maximum elevation in Lake County is 750 feet above sea level, and the minimum elevation is 581 feet above sea level, thus giving a maximum relief of 169 feet. The maximum local relief is 100 feet.

From a study of surface features Lake County is divided into three divisions. The northern one-third of the county is known as the Calumet Lacustrine section. It is the area south of the head of Lake Michigan which was once covered with lake waters. The southern boundary of the old lake is known as Glenwood beach. Blatchley (127) has described the geology of Lake County.

(127)
Blatchley, W. S. Geology of Lake and Porter Counties, Indiana. 22nd Annual Rept., Indi. Geol. Survey for 1897, pp. 20-41.

The present Calumet River flows through this area from east to west. The present topography is due to the old lake deposits of glacial times plus the eroding action of post-glacial erosional elements. This entire Calumet Lacustrine section is marked by a series of low ridges which represent the various successive stages in the withdrawal of the old Lake Chicago from this area. Dunes occur from Gary eastward around the lake margin.

The middle region of Lake County is known as the Valparaiso Moraine Section. There are three distinct belts of moraine which cross the county from west to east, with two intervening belts of till plain. Cedar Lake occurs in the depression of the morainal materials; also, Fancher Lake.

The southern third of Lake County is a part of the Kankakee Lucustrine section which consists of marshy areas and artifically drained farm lands. The Kankakee River Valley was a ponded area during the retreat of the last ice sheet, and the proximity to the present Kankakee River explains the swampy land area.

Drainage. --The drainage of the northern part of Lake County passes into Lake Michigan. The divide is in the region of Crown Point. That portion lying north of the divide between the lake and the Kankakee River goes northward through short small streams

into the lake. The southern half of the county is drained by a number of ditches. The main Singleton ditch heads in the east-central part of the county and extends south and southwest to enter the Kankakee River about one mile from the southwestern corner of Lake County. Brown Ditch, a branch of Singleton, rises in the southeastern corner and extends west and southwest to join the Singleton in the southern part of west Township. Grieset ditch is a small branch of the Singleton ditch which extends southwestward into the latter. Cedar Creek ditch flows southwar from Cedar Lake to enter Singleton ditch.

West Creek, West Creek ditch, and Alderman ditch are branche of the Singleton ditch which drain the southwestern part of the county. North of the divide Deep River rises southeast of Crown Point and flows northward to enter the Little Calumet River about 3 miles from the east county line. The Little Calumet flows in a westerly direction across the county at a distance of about 4 miles south of the north line of the county. About 3 miles north and parallel with it is the Grand Calumet River which flows eastward and empties into Lake Michigan about 2 miles west of the northeast corner of the County. Wolf Lake in the northwestern portion is connected with Lake Michigan by canal. Lake George is also nearby.

GEOLOGY

The unconsolidated deposits of Lake County consist of glacial deposits and lacustrine deposits; also, those along the present Kankakee River which are glacio-fluviatile in origin. Borings for artesian water or for natural gas, made at Hammond, Hobart, and Crown Point, penetrate 110, 160, and 176 feet of drift, respectively. A well drilled near Highland, Section 27, Twp. 36 North, Range 9 west, penetrated 150 feet of glacial drift A well drilled at Indiana Harbor by the Youngstown Sheet & Tube Company logged 45 feet of sand and 60 feet of black clay overlyin the dark gray Devonian shales.

The bedrock strata which are not exposed in Lake County are of Silurian and of Devonian age. From a study of well cuttings and well logs, it is believed that the southern half of Lake County is underlain by strata of Silurian age and that the northern half of the county is underlain by strata of Devonian ag A well drilled for the Grasselli Chemical Company at East Chicago shows 110 feet of shale and argillaceous limestone above the typical Niagaran (Silurian). This shale and clayey limestone contained spores of plants called Sporangites, which have usually been considered indicative of Devonian age, Also, the well drilled to 1683 feet for the Youngstown Sheet and Tube Company at Indiana Harbor logged black to dark gray shale underlying the glacial clays and sands, which, in all probability, are Devonian

in age. The Niagaran (Silurian) limestone is the underlying rock formation of Cook County (Illinois). See Bulletin #34, Illinois State Geological Survey, "Artesian Waters of Northeastern Illinois," by Carl B. Anderson, p. 82. The author of this publication refers to the finding of certain Devonian fossils just over the western boundary of Cook County, Illinois, in Du Page County, and also refers to the fact that Stony Island in southern Chicago is of Niagaran age. Well records in Cook County, Illinois, indicate that the Niagaran strata of that county range in thickness from 100 to 450 feet, so this fact assists in the probable explanation of the discrepancies relating to the underlying formations in this and adjacent areas. Erosion by pre-glacial agents or glacial agents removed in part the surface strata.

General Geologic Section

Quaternary:		
	Recent, sands, clays, and gravels.	0-100'
	Pleistocene, sands, clays, gravels	73-300'
Devonian:	shales, limestones, sandstones (No outcrops).	150'
Silurian:	limestones (No outcrops)	300'
Ordovician:	limestones, shales, and sandstones (No outcrops)	820'

The upper surface of the Trenton limestone lies at an elevation of 183 feet below sea level at Crown Point. In the southwestern part of the county and again in the north-eastern corner of the county the elevation is about 200 feet below sea level apparently determined from data obtained from deep wells.

This portion of northwestern Indiana is located on an anticlinal structure which enters the state from the Wisconsin highlands by way of Chicago, known to some as the Kankakee Arch. It is believed that the Ordovician, Silurian, and Devonian formations overlap on to the Kankakee Arch. Present indications point to a granitic ridge as the possible origin of the arch.

SOURCES OF WATER SUPPLY

Surface water supplies may be obtained from streams, springs, and lakes in Lake County. The largest source of supply is Lake Michigan, which forms the northern boundary of the county. Wolf Lake and Lake George are in the northern part of North Township; Cedar Lake is partly in Center and partly in Hanover Townships; and Long Lake is in Hobart Township. Fanchor Lake is located in the Lake County fair grounds, northwest quarter of Section 17, T. 34 N, R. 8 west, one mile south of Crown Point. It is located on the crest of the moraine and fills a kettle-hole in the moraine.

The waters of the surface deposits are locally of importance. The surface drainage and the character and thickness of the unconsolidated deposits are the controlling factors in determining the quantity of water available. The surface drainage of the entire county is so poor that a large amount of water soaks into the ground. This surface water later finds beds of sand or gravel which act as reservoirs. Especially is this true in the section of the county covered with morainal drift. The average elevation of Lake County is 630 feet above sea level and the elevation of Lake Michigan is given as 581 feet above the sea. The average thickness of glacial drift in Lake County has been estimated to be 150 feet, which would make the average elevation of the surface bedrock 100 feet below Lake Michigan water level, if the unconsolidated deposits were removed. It is known that the thickness of the drift varies, and, as there is little surface relief over large areas in Lake County, these variations in the thickness of the drift indicate that the underlying rock surface has prominences and depressions.

The Devonian shales are the underlying rock formation in northern Lake County and is the youngest of the indurated strata. These shales are very compact and are not considered as water-bearing formations. Well records show this black shale to be approximately 75 feet in thickness.

The formation underlying the Devonian black shale is the Devonian limestones and sandstones which approximate 80 feet in thickness according to well records. If not polluted from salt water horizons deeper down in the geologic column, fresh water should be obtained from the Devonian limestones and sandstones. The black shale cover would seal in the formation from above and at distances from the contact with the glacial drift or natural outcrops, artesian conditions would prevail.

The Silurian (Niagaran) limestone is the underlying rock formation in the southern part of Lake County. The nearest outcrops of Niagaran strata are in Pulaski County, Indiana, some two miles southeast of Francesville, at Stony Island, in the southern part of Chicago; and at Willow Springs, Illinois, along the Desplaines River.

The Niagaran limestone is a fair aquifer, especially in that part of the state where it lies immediately beneath the glacial drift. The Niagaran wells are not large yielders; however, 15 to 20 gallons per minute is an average well and where crevices are encountered some of the wells yield as much as 75 gallons per minute. Some of the Silurian wells were found to be a bit brackish at first; however, continued pumping and flowing seemed to eliminate the objectionable qualities and the wells flowed fresh water after a few days.

The Ordovician formations, consisting of the Cincinnatian shales and limestones and the Trenton formations, are known to bear some water. The Trenton, where porous, contains salt water in many localities in Indiana, and on structure is known to bear oil and gas. We know little about the Trenton in northwestern Indiana due to the few wells and records which are available. The Richmond shales of the Upper Ordovician are not capable of yielding water. The Richmond shales serve as an impervious stratum separating the waters of the Niagaran limestone from those of the Trenton formations.

In the Chicago area the Trenton formations contain some water; however, they are not considered to be sources of ground water. It is the usual practice to leave this formation uncased and Anderson (Bulletin 34, Illinois Geological Survey, p. 86) states that it is probable that more water is lost through crevices than is gained.

In the well drilled at Indiana Harbor by the Youngstown Sheet & Tube Company the St. Peter sandstone was penetrated at a depth of 1065 feet and the total thickness was 135 feet. A well drilled at East Chicago showed 64 feet of St. Peter. One drilled at Grasmere showed 80 feet of St. Peter sandstone, and one drilled at Highland showed 67 feet of St. Peter sandstone. It is difficult to explain the varying thickness of the St. Peter in so limited an area. There are three possible sources of explanation. The first is that error has been made in the logs brought to our attention. The second possibility is that the formation underlying the St. Peter presented an irregular surface on which the St. Peter was deposited. The third possibility is that the surface of the St. Peter is quite uneven.

In certain areas the St. Peter is an important aquifer. This is true in Iowa, Illinois, and Wisconsin. In Chicago many wells tapped the St. Peter and soon lowered the level of the water so that it could not be depended upon as a source of supply. C. B. Anderson, Illinois Geological Survey Bulletin 34, cites the fact that the Western Electric Company in 1912 tested a well in Chicago which had 145 feet of St. Peter, and the test indicated that the supply was less than 20 gallons per minute.

Water Supplies of Towns in Lake County

Gary. -- (population 100,426) The Gary Heat, Light & Water Company furnishes water obtained from Lake Michigan to the city of Gary.

Griffith. -- (population 1,176) The town of Griffith owns its water system. One well penetrates the underlying bedrock and at a depth of 336 feet secures a flow of water under hydrostatic pressure. The water stands within 20 feet of the surface.

Aside from a slight taste of sulphur, the water is satisfactory. This supply is believed to be from either Devonian or Silurian limestone.

Lowell. -- (population 1,274) The town of Lowell owns its water system. Tubular wells furnish the supply. Details concerning the wells are unknown.

Crown Point. -- (population 4,046) The city of Crown Point owns its water supply system. Eight wells produce the supply. They are drilled into bedrock, which is penetrated at 200 feet. The water level is reported to be 20 feet below the surface. The wells are 12 inches in diameter. The water is from either Devonian or Silurian limestones, probably the latter. A deep well drilled at Crown Point obtained salty waters from the deeper horizons.

East Gary. -- (population 2,409) No data are available bearing on the water situation in the town of East Gary.

Hobart. -- (population 5,787) The city of Hobart is supplied water by the Hobart Light and Water Company, a private company. Deep River is the source of supply.

New Chicago. -- (population 481) The town of New Chicago is not listed as having a public water supply. No information is available concerning conditions there.

East Chicago. -- (population 54,784) The city of East Chicago owns and operates its water supply. Lake Michigan is the source of the water.

Hammond. -- (population 64,560) The city of Hammond owns and operates its water system. Lake Michigan is the source of supply.

Highland. -- (population 1,553) The town of Highland owns its water system. A deep well drilled at Highland logged 150 feet of sand and drift, though another well logged bedrock at 112 feet. Water is reported 16 feet below the surface. The town supply was reported to be from soapstone. The producing stratum is in doubt. Tubular wells furnish the town supply.

Munster. -- (population 975) The town of Munster owns its water system. One well obtains water from limestone penetrated at 100 feet. The general water level is 50 feet and is lowered by excessive pumping.

Whiting. -- (population 10,880) The city of Whiting owns its water supply plant. Water is obtained from Lake Michigan.

Dyer, -- (population 672) The town of Dyer owns one well rilled into limestone which produces the town supply. Limestone as penetrated at 174 feet. The wells in the community are rtesian. The Dyer supply probably comes from the Huntington olomite.

St. John. -- (population 332) The town of St. John has no ublic water supply system.

Schererville, -- (population 580) The town of Shererville wns its water system. One ten inch well drilled in 1919 to a epth of 200 feet furnishes the supply. The water level is about 0 feet below the surface in most wells in this community. The own supply is probably from the Huntington dolomite.

Schneider. -- (population 264) The town of Schneider owns ts water supply system. One tubular well is the source. No nformation is available concerning the geological conditions.

Typical Wells of Lake County

ocation	Depth	Quality	Quantity	Formation	Construction
36N-R7W					
Sec. 2	27'	Soft	Fair	Gravel	Dug
Sec. 2	70'	"	Poor	"	Drilled
Sec. 32	Supply from Lake				
35N-R7W					
Sec. 18	40- 80'	Soft	Good	Gravel	Drilled
Sec. 32 NE$\frac{1}{4}$	30'	"	"	"	"
34N-R7W					
Sec. 14	40'	"	"	"	"
Sec. 26	40'	"	"	"	Dug
(Wells in this Section were dry at 30' and driven to 40'.)					
34N-R7W					
Sec. 23	300'	Hard	Good	Limestone	Drilled
Sec. 22	300'	"	"	"	"
33N-R7W					
Sec. 10	90'	"	"	Gravel	"
Sec. 11	100'	"	"	"	"
Sec. 14	100'	"	"	"	"
Sec. 27	40'	Soft	Fair	"	"
Sec. 27	25- 30'	"	"	Sand	Driven
32N-R8E					
Sec. 35	190'	Hard	Good	Limestone	Drilled
36N-R7W					
Sec. 2	27'	Soft	"	Gravel	Dug
Sec. 2	70'	(No water at 70'.)			

L A P O R T E C O U N T Y

GENERAL FEATURES

Area 595 aquare miles Population 60,490 (Census of 1930)

La Porte County is located in northwestern Indiana, Its northern boundary is the Indiana-Michigan State line. It is the third county east of the Indiana-Illinois State line. La Porte is the county seat.

The highest elevation in the county is 885 feet above sea level and the lowest is 581, thus giving a mamimum total relief of 304 feet. The maximum local relief is 150 feet. The county is located in the glaciated region and its surface is quite varied. The topography is diversified by sand dunes, morainic ridges, reclaimed marsh land, and rolling prairie land. The pontion of the county adjacent to Lake Michigan is a part of the Calumet Lake section. Just eastward lies the Valparaiso Moraine section, which serves as the divide between Mississippi and St. Lawrence drainage. The morainic belt enters the county a little north of the town of Westville and extends in a northeasterly direction to the borders of St. Joseph County and Michigan. Southeast of the Valparaiso Moraine is the Kankakee Lacustrine section which is a broad gravel outwash plain and alluvial plain bordering the Kankakee River.

The divide between the Lake Michigan drainage and the Kankakee River drainage extends in a northeast-southwest direction in the vicinity of La Porte. The drainage of the north and western slopes is controlled by small streams which flow into Lake Mishigan. The central southern part of the county is drained by Mill Creek, a branch of the Kankakee. Hog Creek drains the southwestern portion of the county. Several smaller streams run into the Kankakee River which is the south boundary of the western half of the county.

GEOLOGY

The bedrock strata of La Porte County are of Devonian age, according to our present information. There are no outcrops and relatively few wells have penetrated the substrata.

The surface formation in the county consists of glacial drift, made up of morainal deposits, glacio-fluviatile deposits, and ordinary till plain materials. The sand dune areas along Lake Michigan are of more recent origin.

Generalized Geologic Section Taken from Well Record
(Well near the northeast corner of La Porte County)

Glacial Drift		1-220'
Devonian shale	220-315	95'

Devonian limestone	315-415	100'
Sandstone (Pendleton)	415-425	10'
Silurian Limestone and shales	425-615	190'
Ordovician(Cincinnatian shales, ls)	615-1085	470'
Trenton Limestone	1085-1540	455'
Sandstone (St. Peter)	1540-1580	20'
Limestone and chert	1560-1738	178'

GROUND WATER

Good supplies of potable water may be obtained from the Recent and Pleistocene formations. The majority of the wells drilled in the county penetrate the glacial drift for water and do not enter bedrock. Ground water is found in th strata of every age underlying the glacial drift; however, i is usually mineralized and unfit for consumption. Devonian limestones and sandstones, Silurian limestones, Ordovician limestones and sandstones, and Cambrian sandstones carry mineralized waters. The formations below the St. Peter of Ordovician age have not been thoroughly tested in this area. The Jordan sandstone of the Upper Cambrian in the area near Chicago, Illinois, furnishes many cities with water. Im mos cases the water occurring in the Jordan sandstone is a hard water; however, with increasing depth it has a tendency to become mineralized. Deeper down into the Cambrain rocks kno as the St. Lawrence and Dresbach carry ground water; however the water is salty and unfit for drinking purposes. As a rule, the Potsdam waters, or Upper Cambrian waters, are unfi for boiler use.

Leverett gives the following information about a gas-well boring at Michigan City:

Dry surface sand	15'
Quicksand	10'
Gravel	5'
Blue till, pebbly and rather hard	167'
Gravel containing cobble and boulders	15'
Sand and gravel with occasional large stones	40'
Limestone, with thin beds of shale, extending to the bottoms of the well	570'
Total	819'

He also states that at a depth of 210 feet a flow of fresh water was obtained from the drift, with a head 15 fee above the surface. The strength of the flow increased down ward to the rock at 250 feet. A strong flow of sulphur wat was obtained from the limestone at about 450 feet.

In the Fifth Annual Report of the Indiana Geological Survey, 1873, pp. 470-471, a well log is given of a boring drilled at the State Penitentiary, 1 mile west of Michigan City. This is given by Dr. Levette as follows:

Surface sand	48'
Clay	4'
Sand	24'
Clay	66'
Sand	30'
Shale	76'
Upper Silurian limestone, with fossils	293½
Total	541½

Levette states that this boring is reported to terminate in a porous limestone rock which furnishes a flow of water strongly impregnated with sulphureted hydrogen. Its head is 22 feet above the surface of the ground; rate of discharge about 300 gallons per minute; temperature 57 degrees Fahrenheit. The well mouth being about 18 feet above the level of Lake Michigan, or 600 feet above tide, the head at this well is 622 feet above tide.

The log of another well drilled on the R. W. Keller farm, west of La Grosse, is as follows:

Drift	41'
Shales	152'
Limestone, Niagaran	640'
Shale	720'
Limestone	780'
Shale	999'
Limestone (Trenton)	1367'
Water at 1055, which filled hole to within 150 feet of surface	
Sandstone (St. Peter	1400'
Limestone (Magnesian, Shakopee)	1495'
Sandstone (New Richmond)	1895'
Limestone (Oneota)	1965'
Cambrian (Jordan Sandstone)	1996'
Total Depth	1996'

At 1003 feet the well started to fill slowly with oil but after shot of 60 quarts no oil showed.

Well #2, on R. W. Keller farm, one mile west of La Crosse:

Surface	34'
Shale	150'
Limestone	640'
Shale	780'
Limestone (Clinton)	800'
Shale	1023'
Total depth	1117'

Much water at 75 feet and also at 1095. Eight and one-fourth inch casing set at 809 feet. The last two logs are published in Department of Conservation Publication #108.

Levette in Water Supply Paper #21, U. S. G. S. calls attention to a notable instance of rise of water in a sand dune above the level of Lake Michigan. Water was found at the Yankee Slide, a dune on the shore of Lake Michigan, in the

west part of Michigan City. Wells on its slope, at an alt tude of 40 or 50 feet above the lake, obtain water at a depth of but 12 feet.

Water Supply Paper #21 also gives the log of a wel drilled 4½ miles south of Michigan City, which is as follo

Yellow till	20'
Dry sand	8-10'
Blue till	85-90'
Sand	50'
Total	165'

Near Lake Michigan wells frequently obtain water at very shallow depths without reaching the bottom of the bea deposits.

Also, it is noticed that throughout the county the water-bearing sands and gravels appear to be local deposit of limited extent, and that they alternate with till. Alon the Valparaiso Moraine wells are obtained usually at depth of 50 feet or less, and sand and gravels are more abundant than till.

Water Supplies of Towns in La Porte County

La Porte. -- (population 15,755) The city of La Po owns its public water system. Three wells furnish the cit supply. The water is from the drift formations at depths varying from 28 to 75 feet. Water is reported to stand at feet below the curb in wells in the city. The general pro of lakes in this area indicates that the water table is no far removed from the surface.

Michigan City. -- (Population 26,735) The city of igan City owns its water supply system. The source of wa Lake Michigan.

La Crosse. -- (Population 650) The town of La Cr has no public water supply.

Westville. -- (population 496) The town of Westvi owns its public water system. Tubular wells furnish the

Long Beach. -- (population 436) The town of Long is supplied with water by a privately owned system. The is obtained from Lake Michigan.

Trail Creek.-- (population 295) The town of Trai Creek has no public water supply system.

Typical Wells of La Porte County

Location	Depth	Quality	Quantity	Formation	Construction
T33N-R4W					
Sec. 17	16'	Hard	Good	Sand	Driven
T34N-R4W					
Sec. 21	12- 16'	"	"	"	"
Sec. 23	25- 30'	"	"	"	"
T36N-R4W					
Sec. 29	40- 50'	"	"	"	"
T34N-R3W					
Sec. 8	30- 45'	"	"	"	"
T35N-R2W					
Sec. 16	25- 30'	Soft	Fair	Gravel	"
Sec. 16	20'	"	"	"	"
Sec. 16	20'	"	"	"	"
T36N-R2W					
Sec. 35	20'	"	"	"	"
Sec. 35	25'	"	"	"	"-- 2 wells
Sec. 35	20'	"	"	"	"
Sec. 35	25'	"	"	"	"
Sec. 23	18- 35'	"	"	"	"
Sec. 13	20- 50'	"	"	"	Drilled
Sec. 6	20- 25'	"	"	"	Driven
T37N-R1W					
Sec. 36	90'	"	Good	"	Drilled
SE¼					
Sec. 36	80'	"	"	"	"
NE¼					
Sec. 36	80- 90'	"	"	"	"
T37N-R1W					
Sec. 18	80'	"	"	"	"
Sec. 31	15- 20'	"	Fair	"	Driven
T38N-R2W					
Sec. 36	110'	"	Good	"	Drilled
SE¼					
Sec. 36	108'	"	"	"	"
Sec. 35	100'	"	"	"	"
SW¼					
Sec. 35	87'	"	"	"	"
T38N-R2W					
Sec. 9	180'	"	"	"	"
Sec. 8	80'	"	"	"	"
Sec. 5	140'	"	"	"	"
T38N-R3W					
Sec. 3	60'	"	"	"	"
Sec. 2	85'	"	"	"	"
T38N-R4W					
Sec. 36	97'	"	"	"	"
Sec. 36	75'	"	"	"	"
Sec. 36	137'	"	"	"	"
Sec. 35	8-60'	"	"	"	"
Sec. 11	80'	"	"	"	"
T37N-R4W					
Sec. 26	150'	"	"	"	"--no water
Sec. 3	150'	"	"	"	"
Sec. 11	68'	"	"	"	"

L A W R E N C E C O U N T Y

GENERAL FEATURES

Area 456 square miles Population 35,583 (Census of 1930)

Lawrence County is situated in the central-southern portion of the State. It is the fourth county north of the Indiana-Kentucky State line and the fourth east of the Indiana Illinois State line. Bedford is the county seat.

The maximum altitude of the county is 900 feet above sea level, and the minimum is 470 feet, thus giving a total maximum relief of 430 feet. The maximum local relief is 350 feet.

Lawrence County presents a variety of topographic forms. Blatchley in the 1905 Report of the Indiana Department of Geology and Natural Resources writes concerning the county: "The eastern and northeastern parts are undulating or gently rolling plateaus drained by deep, narrow valleys; the central region north of White River is hilly; and the western and southwestern are rough and broken."

Drainage. -- The largest stream in Lawrence County is the East Fork of White River which forms a part of the eastern boundary at the point where it enters the county, flows northwestward to leave the county at a point about eight miles north of the southwestern corner. The principal tributary of the White River in Lawrence County is Salt Creek which enters the county a little to the west of the center of the north line and flows south to enter the White River somewhat southwest of the center of the county.

Indian Creek enters the county near the northwest corner and flows southward to enter the White River beyond the western border of the county. Guthrie Creek enters the county near Leesville and flows south and west to enter the White River near Palestine. Back Creek, which is the principal tributary of Guthrie Creek rises about two miles south of Selma and flows south and southwestward into Guthrie Creek about one mile north of Tunnelton.

Sugar Creek rises by two branches in the southeastern part of the county and flows in a northwesterly direction to enter White River east of Lawrenceport. Fish Creek enters the county from the south and flows northward to enter White River at Lawrenceport. Rock Lick Creek flows northeast to White River about a mile southeast of Palestine. Bryant's Creek enters White River in the southwestern part of the county. Leatherwood Creek rises east of Heltonville and flows west and southwest to enter White River south of

Bedford. Little Salt Creek and Pleasant Run and westward flowing branches of Salt Creek in the northern part of the county.

GEOLOGY

Lawrence County is within the unglaciated portion of southern Indiana. The unconsolidated deposits consist chiefly of alluvium deposited along the major streams. White River, Salt Creek, Leatherwood, Guthrie, and Indian creeks have valley flats. During the Pleistocene glacial epoch, Salt Creek and the East Fork of White River were glacial waterways. Materials were washed out from the ice front and much of the debris was carried into the driftless area by waters. Terraces were formed of the alluvium. Springs are common on the streamward side of these deposits.

The bedrock formations of the county consist chiefly of rocks of Mississippian age. Small, disconnected outcrops of Pennsylvanian (Pottsville) sediments occur on some of the higher hills in the western part of the county. Starting at the eastern border of the county and crossing westward occur outcrops of Borden, Harrodsburg, Salem, St. Louis, Ste. Genevieve, and parts of the Chester series. The Pottsville strata are still higher in the geologic column.

Generalized Geologic Column for Lawrence County

Quaternary:	
Recent, -- alluvium	0-20'
Pleistocene, -- terrace deposits	0-50'
Pennsylvanian:	
Pottsville, -- (Chiefly outliers)	50'
Mississippian:	
Chester	200'+
Ste. Genevieve	100'±
St. Louis	100'
Salem	50-60'
Harrodsburg	75'
Borden	600'+
Rockford (Not exposed)	2-5'

GROUND WATER

Ground waters may be obtained in Lawrence County from the following stratigraphic horizons:

Recent sands and gravels
Pleistocene sand and gravels
Chester sandstones and limestones
Other Mississippian limestones
Borden siltstones -- very poor, bothe in quality and quantity
Devonian limestones -- mineralized
Ordovician limestones -- mineralized.

Shallow well waters are sometimes obtained at the contact between the limestone and a residual clay. In the

valleys of the larger streams water may be obtained from sands and gravels of Pleistocene origin, and also in the alluvial valley-flats of more recent origin.

The Chester limestones and sandstones often contain ground water. Springs occur at the base of the limestone beds and also at the base of the sandstone strata, where they rest on impervious shale.

There are several levels at which ground water is found in the Mississippian system of rocks. These levels are at the top of the Borden, at the top of the Salem and at the top of the Harrodsburg.

The large spring at the Avoca fish hatchery in Lawrence County occurs about 50 feet above the contact between the Salem limestone and the overlying St. Louis limestone. This is an immense spring and water gushes forth in tremendous volume.

In the 26th Annual Report of the Indiana Department of Geology and Natural Resources, (page 75), W. S. Blatchley describes a saline-sulphuretted water from a spring in Avoca as follows: "The spring which yields the mineral water at Avoca emerges from the base of a stratum of Harrodsburg limestone on the east branch of Goose Creek, Section 31, T. 6N., R. 1 W."

Other mineral springs described and mentioned in Lawrence County were located on the estate of Dr. Denson, one mile southwest of Bedford and still others in the bed of Indian Creek in the southeast quarter Section 17, T. 5 N., Range 2 West, near the old Gray's Mill.

Many attempts to secure ground water from wells drilled into the Mississippian limestones have been failures. Several of the wells will produce small quantities of water but in many cases not enough to supply the average family for home consumption. The reason for the failures is as follows: In the eastern part of the county, also in the central portion of the county, the Borden rocks underlie the Mississippian limestones at a comparatively slight depth. The Borden rocks are impervious and are not aquifers and in places where the Borden is pervious the water is mineralized.

Several deep wells have been drilled in Lawrence County prospecting for oil and gas. Devonian, Silurian and Ordovician strata have been penetrated. The deeper strata bear mineralized waters unfit for domestic use, hence cannot be considered as potential sources of supply. Also the extent and thickness of outcrop of the overlying limestones, above the Borden series, are not sufficient to provide gathering ground for water in large quantities. Also the region is dissected by valleys so that any ground water would seep out and be lost to lower streams. Then the St. Louis, Ste. Genevieve and Salem limestones are cavernous and shallow wells are a failure except where they strike

underground streams and such supplies are not usually to be desired from a sanitary viewpoint. Then deeper wells produce mineral water.

Cumings (128) has discussed some of the pertinent

(128) Cumings, E. R. The Geological Conditions of Municipal Water Supply in the Driftless Area of Southern Indiana, Proc. Ind. Acad. Sci., 1911, pp. 111-46.

features of the limestone area as follows:

"In the western edge of the area, where the limestones are under cover of the Chester formation, except in the deeper valleys, the rock-water is artesian and more or less impregnated with mineral salts, as in the case of the water of the French Lick Valley. In this part of the area mineral water is constantly making its way from considerable depths to the surface, along the joints of the soluble limestone, and consequently mineral springs abound, and even shallow wells produce mineral water.

"It is perhaps within the purpose of this paper to point out some special characteristics of the springs of the limestone region. They are usually overrated and their nature and cause misunderstood. All of the large springs of the limestone region are the outlets of subterranean solution channels in the rock and very often serve also as the mouths of well-defined caves. These caves and channels are in turn, as already shown, intimately connected with the sinkholes of the region. The sinkholes are the main gathering grounds of the waters that emerge at the springs. Or, to be more precise, they are the avenues through which the water is taken under ground. The sinks, like the caves themselves, are largely the work of solution. Where the sinks are open at the bottom, as is usually the case, storm water passes very readily and very quickly into the subterranean channels and as quickly emerges at the springs. At such times the spring water is muddy, showing that it is merely surface water that has made a journey of greater or less length through an underground conduit."

Typical Water Supplies of Lawrence County

Township Section	Quality	Depth	Formation
Bono			
SE¼ 30-4-2	---	---	Spring
NE¼ 31-4-2	---	216'	---
SW¼ 32-4-2	---	167	---

Bono			
SW¼ 31-4-2	---	---	Spring
SW¼ 31-4-2	---	200	---
NE¼ 36-4-1	---	187	---
NW¼ 5-3-2	---	120	---
SE¼ 36-4-1	---	70	---
SW¼ 12-3-1	Hard	40	Limestone
Stonington	---	90	---
NE¼ 3-3-1	---	90	---
SW¼ 34-4-1	---	---	Spring
NW¼ 5-3-1	---	---	Cave water
Flinn			
Leesville	Hard	15,50,60 75,112	Limestone
SE¼ 10-5N-2E	"	47	"
SE¼ 9-5-2E	"	39	"
SE¼ 8-5-2E	Soft		Spring & Cistern
SE¼ 7-5-2E	Hard	68	& cistern
SE¼ 11-5-1E	Soft	---	Cistern
Flinn			
SE¼ 12-5-1E	Hard	106'	---
Guthrie			
SE¼ 8-4-1E	---	65	---
SW¼ 9-4-1E	---	78	---
Buddha	---	92,93,125	---
SW¼ 10-4-1E	Soft	---	Cistern
NE¼ 15-4-1E	---	80	---
NW¼ 14-4-1E	---	112	---
NW¼ 13-4-1E	---	195	---
SW¼ 18-4-2E	Hard	25	& spring
Tunnelton	---	12,50,75,200	---
Shawswick			
SW¼ 10-5-1E	Soft	---	Cistern
SE¼ 9-5-1E	---	75	---
SE¼ 8-5-1E	---	25	& cistern
SE¼ 7-5-1E	---	55	---
SE¼ 13-5-1W	Salt	140	---
SE¼ 19-5-1E	---	---	Spring
NW¼ 29-5-1E	---	---	Spring
SW¼ 20-5-1E	---	40	---
SW¼ 29-5-1E	Soft	---	Cistern
SW¼ 32-5-1E	---	60	---

Water Supplies of Towns in Lawrence County

Bedford. -- (population 13, 208) The city of Bedford owns its water supply system. The supply is obtained from White River. The city has a settling basin of concrete construction which holds 3,000,000 gallons. Aluminum sulphate is used to flocculate sediments and chlorine added for purification. Bedford has a dependable source of water, because of its proximity to White River.

Oolitic. -- (population 1,210) The town of Oolitic

owns its water supply system. Water is purchased from the city of Bedford and pumped into the Oolitic mains. The supply is the same as that in use by Bedford.

Mitchell. -- (population 3, 266) The city of Mitchell has a municipal water department, which obtains the public water supply from the East Fork of White River.

Huron. -- (population 245) The town of Huron has no public water supply system.

MADISON COUNTY

GENERAL FEATURES

Area 450 square miles Population 82,888(Census of 1930)

Madison County is located in eastern central Indiana. It is the fifth county south of the Indiana-Michigan State line and the third county west of the Indiana-Ohio State line. Anderson is the county seat. The county has an average elevation of approximately 855 feet above sea level, the maximum relief is about 195 feet. The surface is fairly level except where incised by stream valleys. White River Valley in most places is less than 100 feet in depth, and usually not more than one-half mile in width. The uplands are flat and undissected. Morainal material is generally absent, except in the northeastern corner of the county. The Union City moraine extending southeast-northwest crosses a corner of the county.

Drainage.--The county lies wholly within the drainage basin of the West Fork of White River. This stream crosses the county from east to west somewhat south of the center of the county. Fall Creek and Lick Creek flow southwestward through the southern part and unite near the southwestern corner of the county. Kill Buck Creek flows southwestward and enters White River at Anderson. Its chief tributary is Little Kill Buck Creek which enters the parent stream about three miles north of Anderson. Pipe Creek is joined by Mud Creek near Alexandria and flows southwestward to enter the West Fork of White River near the western boundary of the county. Buck Creek and its branches drain the northwestern part of the county. Sand Creek drains a portion of the western part of the county.

GEOLOGY

The glacial drift which covers the county is a compact till. In many areas bedrock has been penetrated in wells at depths of 50 feet or less, however, a few deep drift deposits indicate the existence of preglacial channels and irregularities. A section of drift near Halford measured almost 500 feet in thickness. The average thickness of the till is about 100 feet. The till consists of a pebbly clay, however, contains gravel and sand in sufficient quantities for water source beds.

The bedrock which underlies Madison County has been mapped by the Indiana Geological Survey as Silurian. One lone outlier of Devonian outcrops at Pendleton. The Pendleton sandstone has been determined to be of Schoharie age. Little is known of its areal distribution, even in Madison County. It has been reported from several logs of wells.

Outcrops of bedrock occur in Sections 23, 24, and 29

in Township 21 N., Range 7 East; in Section 34, T. 20 N., Range 6 East; in Section 3, 13, 21, Township 19 North, Range 6 East; in Section 11, Township 19 N., Range 11 East; in Sections 20 and 30, Township 18 North, Range 7 East; and in Section 6, Township 17 North, Range 6 East.

Generalized Geologic Section for Madison County

Quaternary:
Recent, -- chiefly alluvium . . . . . 0- 20'
Pleistocene . . . . . 0-450'
Silurian: (Part of Silurian exposed)
Liston Creek, -- limestone (Exposed in quarry)
Mississinewa, -- shale (Exposed in quarry)

GROUND WATER

Glacial gravels in the drift and limestone bedrock share about equally in supplying ground water to the citizens of the county. Important alluvial beds are found only along the bottoms of White River and Fall and Pipe Creeks. These range in width from a few feet to about one-half mile. Wells which penetrate the alluvium are usually shallow.

Many dug wells are in use, however, as the deeper wells furnish more satisfactory supplies, they are in more general use. The till will permit water to slowly seep into wells. Experience has shown that the deeper wells invariably penetrate gravel or sand, which amply repays in more copious supplies.

Flowing wells have been drilled in various localities in Madison County, especially where the well was located in a valley. Most of the flowing artesian waters come from the Silurian limestone. Much prospecting for oil and gas in this county has determined the water containing properties of the various formations. The valley of White River both above and below Anderson has had flowing wells. In the western part of the county a very few wells flow from the glacial drift horizons. The drift acts as a gathering area for the Silurian limestone. The water from precipitation goes into the ground and percolates downward and finally enters the cavities in the limestone formation. It is possible that some lateral movement down the dip, brings water from the northeast, through it is believed that precipitation within this county is the chief source of supply.

Generalized Geologic Section for Madison County

Anderson.-- (population 39,804) The city of Anderson has a municipal water department. The water is obtained from deep wells and from White River. Bedrock is penetrated at 134 feet. Two wells drilled in the summer of 1928 furnish 1,500,000 gallons per day. The wells are cased with 25 inch casing. The water has a slight taste of iron, otherwise is

of excellent quality. Private wells in the city range in depth from 18 to 350 feet. Springs exist in the White River Valley in this vicinity. Most of the ground water supply in Anderson at the present time is obtained from the glacial drift and alluvial materials of White River Valley flat.

Elwood. -- (population 10,685) The public water supply of Elwood is privately owned. Several drilled wells producing from the Silurian limestone furnish the supply. Many private wells varying in depth from 20 to 50 feet are in use. Limestone is reported at depths of 60 to 150 feet below the surface.

Alexandria. -- (population 4,408) The city of Alexandria owns its public water supply. Nine wells produce from the Silurian strata. The bedrock is reported to be from 40 to 75 feet and water rises to within 5 to 15 feet of the surface. The supply varies with the seasons.

Frankton. -- (population 829) The city of Frankton owns one dug well, depth 25 feet. This well produces from the gravels in Pipe Creek valley. The well is 24 inches in diameter. Many private wells secure water from about the same stratigraphic position, the depth varying according to the surface location.

Lapel. -- (population 1,140) The town of Lapel owns one well, reported to produce 776,000 gallons per day from limestone strata at 226 feet. Rock is found at 18 feet. Many private wells are in use.

Summitville. -- (population 1,017) The town of Summitville is supplied water from three wells, privately owned. The water comes from the Silurian limestone, which is penetrated at 80 feet. Many privately owned dug wells obtain water at a few feet in drift.

Pendleton. -- (population 1,538) The town of Pendleton owns its water supply system. One tubular well furnishes the supply. Outcrops of Silurian and Devonian formations occur at Pendleton.

The Indiana Reformatory well No. 2, Twp. 18 N., R. 7 East, was completed in 1928 and abandoned because of the salty water. The log follows:

Gravel and soil to	45 feet	
Limestone.	360 "	
Shale.	905 "	
Limestone.	924 "	-- salt water horizon

This well is reported to have terminated in the so-called Trenton formation of Ordovician age.

Chesterfield. -- (population 460) The town of Chesterfiel owns its water system. Tubular wells furnish the supply.

Other towns in Madison County are Orestes (population 357) Gimco City, (population 15); Aladdin, (population 28); and Ingalls, (population 430); none of which has a public water sys

Typical Wells in Madison County

Location	Depth	Quality	Quantity	Formation	Construction
T19N-R8E Sec. 14	20-350'	Hard	Abundant	Gravel & limestone	Driven & Drille
T21N-R6E Sec. 15	15-400'	"	"	Sand & limestone	" "
T21N-R7E Sec. 24	350'	"	"	Limestone	"
Sec. 31	20'	Medium	"	Gravel	Dug, Driven, & drilled
T22N-R8E Sec. 16	347'	Hard	"	Limestone	Drilled
T18N-R7E Sec. 20	25- 40'	"	"	Gravel	
T19N-R6E Sec. 28	30- 90'	"	"	Gravel & limestone	Driven & Drille
T21N-R7E Sec. 15	15- 70'	"	"	Gravel & limestone	" "
T17N-R6E Sec. 1	40-100'	"	"	Gravel & limestone	" "
Alliance	20- 30'	"	"	Gravel & limestone	" "
T19N-R8E Sec. 10	20-400'	"	"	Gravel & limestone	" "
T21N-R7E Sec. 17	18- 75'	"	"	Gravel & limestone	" "
T18N-R8E Sec. 17	15-110'	"	"	Gravel	" "
T19N-R6E Sec. 34	35-140'	"	"	Gravel & limestone	" "
T20N-R7E Sec. 26	25- 65	"	"	Gravel	" "
T21N-R8E Sec. 36	15- 45	"	"	Gravel -- at 64'	" "

Location	Depth	Quality	Quantity	Formation	Construction
T22N-R6E Sec. 9	20- 55'	Hard	Abundant	Gravel & limestone	Driven & Drilled
T20N-R7E Sec. 12	20- 90'	"	"	Gravel	" "
T18N-R8E Sec. 28	15-115'	"	"	Gravel & limestone	" "
New Columbia	30-120'	"	"	Gravel-- rock at 140'	" "
T20N-R6E Sec. 33	20-130'	"	"	Gravel & limestone	" "
Perkinsville	20-100'		Water in	Gravel	
	100-130'			Limestone	
New Columbia	30-120'		Water in	Gravel -- rock at 1408'	
Markleville	15-120'		Water in	Gravel	
	100-115'			Limestone	
Linwood	20- 90'		Water in	Gravel	
Leisure	20- 25'		Water in	Gravel	
	25- 55'			Limestone	
Gilman	15- 45'		Water in	Gravel -- rock at 64'	
Florida	25- 65'		Water in	Gravel	
Fishersburg	35- 70'		Water in	Gravel	
	70-140'			Limestone	
Emporia	15-110'		Water in	Gravel	
Dundee	18- 50'		Water in	Gravel	
	50- 75'			Limestone	
Chesterfield	20-110'		Water in	Gravel	
	110-400'			Limestone	
Alliance	20- 30'		Water in	Gravel	
Ingalls	40'		Water in	Gravel	
	80-100'			Limestone	
Orestes	15- 30'		Water in	Gravel	
	60- 70'			Limestone	
Lapel	30- 70'		Water in	Gravel	
	50- 90'		Water in	Limestone	
Pendleton	25-140'		Water from	Limestone	
Summitville	347'		Water from	Limestone	
	30- 60'	--shallow wells		Gravel	
Frankton				Water from 20 x 20 well in Gravel	
Alexandria	350'		Water in	Limestone	
Elwood	150-400'		Water in	Limestone	
	15- 20'			Sand	Private wells
Anderson	20-350'				Private wells
	120--rock		Water from	White River	

MINERAL ANALYSES OF WATERS IN MADISON COUNTY(129)

(Parts per million)

Location	Geological conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	Color	Total solids
Alexandria			3.5		152	72		29	201		109	103				
Alexandria			2.5		142	50		22	263		76	63				
Alexandria					83	29		5.9	186		15	6.8				
Alexandria	Limestone	35	16		25	8.3		43	40		77	33				370
Alexandria	Limestone	17	2.5		71	32	17		168		44	17				344
Alexandria	Limestone	14	2.2		119	49	214		265		55	327			1	1052
Alexandria	Limestone		.40		22	53				335	190	62	5	.0012		805
Alexandria	Limestone		.4		134	33				342	158	44	3	.002		704
Anderson	Limestone				75	34		1.4(?)			12	7				385
Anderson	Limestone	22	2.6		56	35		13		273	58	12				347
So. Anderson	Limestone	5.6		8.4	104	14		24	190		36	12				401
Anderson	Gravel				140	24				316	134	23	2.5	.004		566
Elwood	Limestone	1.2		6.8	77	30	6.7		173		30	10				344
Elwood	Limestone	11	.77		121	38	4.3		160		176	6.7				523
Elwood	Limestone	16	5.5		82	37	13		179		59	19				440
Elwood	Limestone		2.4		84	33	16		213		16	4.8				
Frankton	Limestone				111					305	148	23	2.5	.02	2	650
Gilman	Gravel		1.4		25	42				413	37	17	.1	.0014		488
Ingalls	Limestone		.8		83	29				306	7	2	.1			360
Ingalls	Limestone		1.2		103	28				241	61	112		.0014		738
Lapel	Limestone		.01		115					360	141	35				468
Leisure	Limestone		.1		110					362	88	22	.1			482
Mounds Park			.8		71	28				305	51	77	.1	.001		332
New Columbus	Limestone		1		57	25				326	28	6			33	394
Orestes	Limestone				97	33				324	237	89	10	.0012		1024

MINERAL ANALYSES OF WATERS IN MADISON COUNTY(CONTINUED)

Location	Geological conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	color	Total soldis	
Pendleton	Limestone				69	32				271	63	8.5	4	.001	5	580	
Pendleton	Limestone				14	23				303	197	1.	1.5		9	494	
Perkinsville	Limestone		.14		76	5				307	86	44		.08		412	
Summitville	Limestone	17	3.9		93	28	.17		209		16	14				402	
Summitville	Gravel				45	72				340	271	168	2	.005		1192	
Summitville	Limestone		1.4		42	36				214	14	14	.2			488	

(129) From Water-Supply Paper 254, p.175.

MARION COUNTY

GENERAL FEATURES

Area 397 square miles Population 422,666 (Census of 1930)

Marion County is located in approximately the geographical center of Indiana. Indianapolis is the county seat.

The maximum altitude in Marion County is 850 feet above sea level and the minimum altitude is 625 feet above sea level, thus giving 225 feet of maximum relief. The maximum local relief is 125 feet. Marion County is a portion of the Tipton Till Plain physiographic unit and topographically the surface varies from a level to gently rolling plain to areas where morainal topography is more prominent. Two broken belts of moraine extend across the county from north to south. The areas of maximum local relief are along the moraines. Crown Hill in Indianapolis stands 125 feet above the valley train plain of White River. The White River bottoms are fairly level, however, the country along Eagle Creek in the northwestern corner of the county is the roughest to be found in the entire county.

Drainage. -- This county lies partly within the drainage basin of the East Fork of White River and partly within the drainage basin of the West Fork of White River. The large part of its area is within the West Fork of White River drainage area, which stream flows across the county trending south twenty degrees west, dividing the county west of the center. In the northwestern portion of the county are Big Eagle Creek, Crooked Creek, and Williams Creek. These are all southward flowing branches of the West Fork of White River. Fall Creek enters the county near the northeastern corner and flows southwestwardly to enter the White River within the city of Indianapolis. Fall Creek receives a northern branch, Mud Creek and a southern branch, Indian Creek. Big Run enters Fall Creek near the northeastern part of Indianapolis.

Pogue's Run, Pleasant Run, Lick Creek, and Buck Creek are streams which enter the West Fork of White River from the east and drain the south-central portion of the county. Grass Creek, a tributary of Sugar Creek in Shelby County, drains the southeastern corner of Marion County. White Creek is a southward flowing stream along the western side of Wayne Township. Bean Creek is a small branch of Pleasant Run. A small pond is located in the valley of the West Fork of White River about two miles northwest of Glen Valley. It is connected to White River by three outlets.

GEOLOGY

The unconsolidated materials of Marion County consist of alluvial deposits which occupy the valley flats along the major streams, valley train outwash deposits and glacial drift.

Leverett calls attention in Water Supply Paper No. 26 to the great gravel plain which stands above the present flood plai of White River. It is two miles or more in width. The city of Indianapolis is located on this terrace.

A large area in Marion County is covered with morainal drif East of White River the moraine surface is characteristic, consisting of kettle and kame topography. West of White River the moraines are not so prominent.

All of Marion County has been glaciated and the remaining areas of the county are mantled with glacial till. It is believed that the till covers the entire county and the alluvial and morainal deposits overlie the till.

The bedrock formations of Marion County consist of Devonian and Mississippian strata. Most of the county is underlain by the Devonian, however, the very southwestern corner of the county, embracing about ten square miles is underlain by Mississippian rocks.

The northeastern one-half of the county is underlain by the Devonian limestones and shales, and the remainder of the county has Devonian black shale immediately underlying the glacial drif with the exception of the small corner occupied by Mississippian strata, which has been previously mentioned.

The dividing line between the Devonian limestones and the Devonian shales occurs within the city of Indianapolis and the contact between these formations strikes approximately north thirty degrees west, or south thirty degrees east. This was noticed in wells drilled many years ago. Dr. R. T. Brown, in the Geological Survey of Marion County, Indiana Department of Geology and Natural History, 1882, calls attention to a well drilled at the Hospital for the Insane which passed through 40 feet of black shale just below the drift and farther east in the city of Indianapolis the black shale was absent and limestone occurred below the drift.

Eastward from Indianapolis the Devonian limestones underlie the drift. This limestone is approximately 50 feet in thickness is quite porous and contains excellent ground water and usually in fair quantities. Underlying the Devonian strata are found the Niagaran limestones, which underlie the drift in parts of Hancock Hamilton, and Madison Counties to the northeast of Marion County

It has been the practice in this region to drill through the Devonian and get water in both Devonian and Niagaran strata.

In the western part of Marion County, where the Devonian black shales (New Albany) underlie the drift, it is necessary to drill through the shale into the underlying limestones in order to secure ground water. The shale is impervious and is not considered an aquifer. At Bridgeport, well records show the black shale to be 124 feet in thickness. Another well located 1½ miles northwest of Bridgeport logged 125 feet of black shale. This same well logged 85 feet of Mississippian strata overlying the black shale and just below the glacial drift.

Generalized Geologic Section for Marion County

Quaternary:	
Recent, -- sands, clays, gravels	0- 40'
Pleistocene, -- sands, clays, gravels	0-150'
Mississippian: shales and limestones	0- 85'
Devonian: shales and limestones	200'
Silurian: limestones	260'
Ordovician shales and limestones (Cincinnatian)	504'
Ordovician, -- (Trenton limestones)	50'

(Above thicknesses determined from well records)

Sources of Water Supply for Marion County

Surface water supplies in Marion County may be obtained from springs and streams. In favorable places these supplies may be augmented by the impounding of surface waters or stream waters. Several springs have been described in the Twelfth Annual Report of the Indiana State Geologist, 1882, p. 90.

Ground water can be secured in Marion County from several geological formations. The alluvial and glacial surface deposits have been used and are still the most prolific sources for a water supply. The Devonian limestones and sandstones and the Silurian limestones are the more important aquifers below the drift. The Ordovician strata carry mineralized water, especially the Trenton, also the St. Peter is full of salt water.

The Indianapolis Water Company has secured water from sixty wells for several years, the water supply coming from the Niagaran and Devonian limestones. The company reports that the wells average 325 feet in depth, which would indicate that the source of water supply is the Niagaran limestone.

The following is a log of a well drilled by the Pennsylvania Railroad Company in April, 1929. The well was located 6.6 miles west of Indianapolis on their right-of-way.

Water Supplies of Towns in Marion County

No data are at hand concerning water supplies of the following Marion County towns:

Beech Grove (population 3,552)
Woodruff Place (population 1,216)
Castleton (population 222)
Rocky Ripple (population 133)
Lawrence (population 840)
Lynhurst (population 51)
Shooters Hill (population 11)
Spring Hills (population 22)
Warren Park (population 164)
Highwoods (population 28)
Ravenswood (population 128)
Crows Nest (population 79)
Southport (population 521)
Clermont (population 448)

Indianapolis. -- (population 364,161) Indianapolis is furnished water by the Indianapolis Water Company, a private corporation. The sources of water supply are White River, Fall Creek and deep wells. Sixty deep wells are in use and the company reports the average depth of the wells to be 325 feet per well. Information supplied by the company shows these wells to range from 120 to 450 feet in depth, with only about three wells less than 250 feet in depth. The wells are capable of furnishing 25,000,000 gallons of water per day, which has been insufficient for the needs of the city, hence the use of river water. The well water is produced from the Silurian limestones.

Speedway. -- (population 1,420) The town of Speedway owns its water supply system. Tubular wells furnish the water.

Typical Wells in Marion County

Location	Depth	Quality	Quantity	Formation	Construction
T16N-R3E Sec. 1	20-364'	Med. hard	Abundant	Gravel & limestone	Driven & Drilled
T17N-R3E Sec. 36	50-115'	"	"	Gravel & limestone	Driven & drilled
T15N-R2E Sec. 16	120'	"	"	Gravel	Driven & drilled
T16N-R4E Sec. 28 F I B. Har	130-380'	"	"	Limestone	Drilled
T14N-R5E Sec. 15	22- 40'	"	Fair	Gravel	Driven
T15N-R2E Sec. 12	15-125'	"	"	"	Driven & drilled
T17N-R4E Sec. 22	10-112'	"	"	"	Driven & drilled
T16N-R2E Sec. 21	15-200'	"	"	"	Driven & drilled
T15N-R3E Sec. 1	15-240'	"	"	" Limestone 240'	Driven & drilled
T16N-R3E Sec. 8	15- 30'	"	"	Gravel	Driven & drilled
T14N-R5E Sec. 6	20-300'	"	"	Gravel & limestone	Driven & drilled
T14N-R3E Sec. 34	30- 50'	"	"	Gravel	Driven & drilled
T16N-R4E Sec. 19	25- 50'	"	"	Gravel	Driven & drilled
T16N-R5E Sec. 7	10- 30'	"	"	Gravel Limestone at 200'	Driven & drilled
T17N-R2E Sec. 25	15-110'	"	"	Gravel	Driven & drilled
T15N-R5E Sec. 31	20-120'	"	"	Gravel	Driven & drilled
T17N-R3E Sec. 24	12-100'	"	Abindant	Gravel & limestone	Driven & drilled

Location	Depth	Quality	Quantity	Formation	Construction
T17N-R5E Sec. 34	15-150'	Med. hard	Fair	Gravel limestone at 160'	Driven & drilled
T14N-R4E Sec. 18	10- 3'	"	"	Gravel	Driven & drilled
T17N-R2E Sec. 16	20- 90'	"	"	Gravel	Driven & drilled
T15N-R2E Sec. 35	15-135'	"	"	Gravel	Driven & drilled
T14N-R2E Sec. 16	15-215'	"	"	Gravel Limestone at 184'	Driven & drilled
Acton	22- 40'		Water in gravel		
Ben Davis	15-125'		" "	"	
Castleton	10-112		" "	"	
Clermont	15-200'		" "	"	
Cumberland	15-240'		" "	"	
	240'			Limestone	
Flackville	15- 30'		Water in gravel		
Gallandet	---		---		
Glens Valley	30- 50'		Water in gravel		
Howland Station	25- 50'		" "	"	
Lawrence	10- 30		" "	"	
	200'		" "	limestone	
New Augusta	15-110'		" "	gravel	
New Bethel	20-120'		" "	"	
Nora	12- 80'		" "	"	
	80-100'		" "	limestone	
Oaklandon	15-150'		" "	gravel	
	160'			Limestone	
Southport	10- 35'		" "	gravel	
Traders Point	20- 90'		" "	"	
Valley Mills	15-135'		" "	"	
West Newton	15-215'		" "	"	
	184'			Limestone	
Ft. Benj. Harrison	120'			Limestone	
Brightwood	130-380'			Limestone	
Bridgeport	100'			Gravel	
Broadripple	50'		Water in drift		
	115'		" "	limestone	
Indianapolis	273-364'		" "	"	

33 wells and White River

(Parts per million)

Location	Geological conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total solids
Broadripple	Gravel															
Flackville	Gravel		.8		117	26				315	69	33		.001	2	488
Indianapolis			.2		64	16				267	57	40		.001		308
Indianapolis		22		39	120	44	85		199		138	130				793
Indianapolis		7.2	2.		123	31			2072		112	21				359
Indianapolis	Limestone	13	1.4		142	45			248		147	51				697
Indianapolis	Limestone	32	118		76	34			216		19	6.7				
Indianapolis	Gravel	12	7.7		130	42			233		107	51				
Indianapolis	Gravel	11	2.1		106	31			163		111	17				460
Indianapolis	Gravel	10	2.2		127	46			187		230	99				793
Indianapolis	Gravel	15			143	46					113	99				747
Indianapolis	Gravel	1.4	3.9		63	34			210		3.2	10				366
Indianapolis	Gravel	7.4	2.		127	47			223		96(?)	50				792
Indianapolis	Gravel	19	Tr.		96	35	11		227		19	10				414
Indianapolis	Gravel	7.2	11		119	44	21				100	31				
Indianapolis			32		43	23					34	Tr.	Tr.			360
Indianapolis	Limestone	28	14		175	52			620(?)		91	78	Tr.			537
Indianapolis				3.2	86	30	24		147		100	27				
Indianapolis					91	32	27		171		96	25				
Indianapolis				2.7	68	24	5.5		129		42	8.5	11			
Indianapolis		9.6	3.4		85	31	31		169		54	48				
Indianapolis		14	2.2		70	46	7.9		205		24	12				
Indianapolis		14	.3		78	44	7.9		205		38	12				401
Indianapolis	Limestone	18	Tr.		60	36	60			344	95	18	2.5			466
Indianapolis	Limestone	16	.2		104	48	60			310	186	80	21			722
Indianapolis	Limestone				64	27	30			406	5.6	5.2	2.7			365
New Augusta					95	18				299	124	10			2	328

(130) From Water-Supply Pa per 254, p. 185.

M A R S H A L L C O U N T Y

GENERAL FEATURES

rea 441 square miles Population 25,077 (Census of (1930)

Marshall County is located in central northern Indiana, the econd county from the Michigan-Indiana state line and the fourth rom the Indiana-Illinois state line, likewise the fourth from the hio-Indiana state line.

Yellow River, a branch of the Kankakee River, flows in a outhwesterly direction across Marshall County. It drains about hree-fourths of the surface of the entire county. Tippecanoe iver crosses the southeast corner of the county and has a few mall tributary streams flowing from Marshall County. Pine Creek, tributary of the Kankakee, drains the northwestern part of the ounty, also Yellow Bank Creek is in this general area.

Marshall County has a maximum elevation of 895 feet and a inimum elevation of 705 feet, thus giving a total maximum relief f 190 feet. The maximum local relief is 100 feet. The county s plateau-like, especially the eastern half. The western half of he county is covered by the Maxinkuckee Moraine, which extends outhward from the St. Joseph River. The western margin of Mar- hall County was included in the old glacial Lake Kankakee and the resent remnants are sandy plain areas.

There are many lakes in Marshall County, all of which occupy asins in the morainal material or in adjacent areas where the mo- raines obstructed the drainage. Lake Maxinkuckee, in the south- western township of the county, is the most noted and has an area f approximately three square miles. A report on Lake Maxinkuckee, Physical and Biological Survey, by Everman and Clark, Dept. of Conservation, State of Indiana, Publication #7, is available for reference and describes in detail this famous lake.

GEOLOGY

The glacial drift covers the surface of Marshall County. The drift attains a thickness of more than 250 feet. In several portions of the county the immediate surface drift has been modi- fied by glacio-fluviatile action and by recent stream action. In the Yellow River valley the deposits range from a few rods to one- half mile in width. These deposits are typical alluvial river valley deposits. Along the west edge of the county the Kankakee- Lacustrine plain is developed and is included in the physiographic unit by that name. Also locally sand dune topograghy is conspicu- ous notably along the margins of the old lake deposit.

The surface of the eastern one-half of the county consist sand and gravels and associated till. Morainal drift covers mo of the western half of the county. Artesian wells are found in the morainal areas. In the east half and in the northwest part the county the till deposits exceed 200 feet in thickness. Loc ally boulders cover the morainal deposits. Marsh areas in vari portions of the county have been drained. They were due to po ing due to imperfect drainage.

Only a few deep wells have penetrated the bedrock of Mar shall County, which consists of Devonian shales immediately und lying the drift. The dip of the bedrock is toward the northeas A contour map on the upper surface of the Trenton limestone sho this horizon to be 300 feet below sea level near the extreme so western corner of the county and the same horizon to be 700 fee below sea level in the extreme northeastern corner of the count

The following geological divisions have been recognized i well records:

Quaternary:

Recent, -- sands, clays and gravels
Pleistocene, -- sands, gravels, clays
Devonian: shales (New Albany), limestones (Sellersburg, Jeffer ville), sandstone (Pendleton)
Silurian: Niagaran limestones and shales
Ordovician: limestone (Richmond), shales, limestone (Trenton).

Sources of Water Supply

Surface water supplies may be obtained in Marshall County from springs, streams and lakes. Many of the streams are perma nent since they are the outlets of lakes.

Lakes are located in several townships. Maxinkuckee is l cated in Union Township; Twin Lakes in West and partly in Centr Township; Lake of the Woods partly in North and the remainder i German Township; Manitou lies partly in Union Township and part in North Bend Township, Starke County; Pretty Lake is in West Township; and Mill Pond in Tippecanoe Township. Many small pon also exist in the county.

GROUND WATER

Ground water supplies exist in abundance in Marshall Coun The valley of Yellow River above and below Plymouth has severa tesian wells which produce from the gravels below the till and ley alluvium. At the city water works wells in Plymouth water and stands within four feet of the curb of the wells. Another tesian belt is found on the shores of Lake Maxinkuckee and the and north shores have been especially prolific of flowing well These wells range in depth from 27 to 130 feet, with the major between 50 and 80 feet. The artesian wells are obtained in gr underlying clayey drift. Culver Military Academy has several w producing an abundance of good water from a depth of 65 feet.

The numerous lakes throughout the county also are fed from ground water sources. At lake Maxinkuckee there are several small springs along the shores and probably a good many in the bottom of the lake, however, it is impossible to ascertain how much they contribute to the supply of the lake. In 1920 the sum total of water entering the lake from flowing wells actually measured was 576,000 gallons per twenty-four hours. Various tributary creeks contribute 400 gallons per minute, thus making a total of 1,152,000 gallons daily added to Lake Maxinkuckee.

Water Supplies of Towns in Marshall County

Plymouth. -- (population 5,290) The city of Plymouth obtains a municipal water supply from six wells of varying depths into glacial gravels. Water is reported to stand within four feet of the surface of the wells. The depth of the present supply is unknown, however, the wells are reported to be in the neighborhood of 60 feet, and the wells are six and eight inches in diameter.

A log of a well at the city waterworks at Plymouth is given in Water Supply Paper #854 and is as follows:

Clay	9 feet
Sand and gravel	180 "
Clay	23 "
Limestone	2 "
Shale	107 "
Limestone	

Natural springs are reported plentiful in the vicinity of Plymouth.

Bourbon. -- (population 1,193) Private interests supply the town of Bourbon with water from two wells which produce from gravels. Water stands at about 20 feet below the curb and occurs abundantly at 150 feet, after penetrating beds of till, sand and gravel. Many private wells are from 16 to 60 feet and water head is 3 to 30 feet below the ground surface. One report stated that bedrock was found at 90 feet; however, we have been unable to confirm this statement.

Bremen. -- (population 2,105) The town of Bremen obtains a city water supply from two wells producing water from a depth of 48 feet. The gravel from which the water comes is overlain by hardpan and clay thus making the lower gravels an excellent aquifer. The wells were drilled in 1925 and are reported to be standing up well. The water is slightly alkaline. The wells are cased with 12-inch casing. Artesian wells are reported south of Bremen some four miles.

Argos. -- (population) The town of Argos owns three wells which supply water from a fine white sand and gravel at 80 feet in depth. The water stands 25 to 30 feet below the curb of the wells. Private wells are driven from 20 to 120 feet.

Culver. -- (population 1,502) Culver has a municipal water supply derived from four wells at a depth of 70 feet. A few wells nearby flow; however, those located higher on the moraine are of the non-artesian type. The water comes from the gravels in the moraine.

LaPaz. -- (population 375) The town of LaPaz has no public water supply system. The following information has been furnished by Mr. L. P. Kimball, Engineer of Buildings, Baltimore and Ohio Railroad Company, Baltimore, Md.

"At LaPaz Junction, Indiana, a well was developed during the years 1926 to 1928 with the following log. Hard boulder clay to 135 feet with an occasional streak of several feet of sandy clay water bearing sand and gravel 135 feet to 160 feet which is the total depth of the well. The location is adjacent to our Main Line Chicago Division tracks about one mile east of the town of LaPaz. This well is equipped to produce 500,000 gallons per 24 hours if needed, but at present our consumption demands limit this to approximately 95,000 gallons per 24 hours. The static level maintains at 35 feet to water and intermittent pumping reduces this to 60 feet to water."

"The chemical analysis as of November 23, 1921, follows:

	5.00 PM Grains Per Gallon	8.00 PM Grains Per Gallon
Total Solids	22.15	20.99
Chlorin	0.15	0.18
SO-3	0.06	0.06
Alkalinity	14.98	15.04
Hardness	14.57	14.57
Turbidity	6.12	4.96

"Our records also include a deep well at our coal chute with the following analysis: --

	Jan. 29, 1918	June 17, 1927	June 25, 192
Total Solids	90.43	20.70	15.74
Chlorin	2.04	0.06	0.24
SO-3	39.15	0.47	0.35
Alkalinity	13.99	13.82	13.41
Hardness	64.10	15.74	13.91
Turbidity			Very Slight

"A private well 175 feet deep with unknown date has the following analysis.

Total Solids	14.57	14.28
Chlorin	0.23	0.18
SO-3	0.67	Trace
Alkalinity	12.84	13.99
Hardness	9.91	10.20
Turbidity	. . .	. . .

Typical Wells of Marshall County

Location	Depth	Quality	Quantity	Formation	Construction
T35N-R3E, Sec. 35	111'	Hard	Good	Gravel	Drilled
T34N-R2E, Sec. 9	16'	"	"	"	Driven
Sec. 20	59'	"	"	"	"
T35N-R4E, Sec. 4	20-120'	"	"	"	Drilled
Sec. 30	86'	"	"	"	"
T34N-R1E, Sec. 10	45'	"	"	"	Driven
Sec. 18	40'	"	"	"	Drilled
Sec. 20	28- 45'	"	"	"	Drilled and Driven
T33N-R1E, Sec. 32	35- 60'	"	"	"	Drilled and Driven
T32N-R3E, Sec. 5	68- 72'	"	"	"	Drilled
Sec. 12	88'	"	"	"	"
Sec. 15	80'	"	"	"	"
Sec. 16	30'	Soft	"	"	Driven
Sec. 28	30- 35'	"	"	"	"
T33N-R4E, Sec. 19	30'	"	"	"	"
Sec. 24	25- 30'	"	"	"	"
T33N-R3E, Sec. 19	17- 35'	Hard	"	"	"
Sec. 18	37'	"	"	"	"
T33N-R2E, Sec. 11	27'	"	"	"	"
Sec. 17	15-130'	"	"	"	"
T33N-R2E, Sec. 4	60-190'	"	Abundant	Gravel -- limestone at 211'	Dug, driven, and drilled
T35N-R3E, Sec. 11	15-110'	"	"	Gravel -- shale at 180'.	Dug, driven, and drilled

Location	Depth	Quality	Quantity	Formation	Construction
T32N-R2E, Sec. 12	20-120'	Hard	Abundant	Gravel	Dug, driven, and drilled
T33N-R3E, Sec. 24	20-150'	"	"	"	Dug, driven, and drilled
Culver	10-135'	"	"	"	Dug, driven, and drilled
Ayr	40-100'	"	"	"	Dug, driven, and drilled
T32N-R1E, Sec. 4	15- 90'	"	"	"	Dug, driven, and drilled
T34N-R1E, Sec. 30	15- 80'	"	"	"	Dug, driven, and drilled
T34N-R2E, Sec. 4	15- 30'	"	"	"	Driven and drilled
T33N-R3E, Sec. 8	12- 85'	"	"	"	Driven and drilled
T35N-R2E, Sec. 8	40- 50'	"	"	"	Driven and drilled
T32N-R1E, Sec. 23	80-140'	"	"	"	Driven and drilled
T32N-R1E, Sec. 1	20- 50'	"	"	"	Driven and drilled
T35N-R1E, Sec. 23	35- 50'	"	"	"	Driven and drilled
T32N-R4E, Sec. 19	20- 40'	"	"	"	Dug and drille
T34N-R1E, Sec. 22	15-145'	"	"	"	" " "
T32N-R3E, Sec. 32	15- 25'	"	"	"	Dug and drive
Plymouth	60-196'			"	
	211'			Limestone	
Bremen	15-110'			Gravel	
	180'			Shale	
Argos	20-120'			Gravel	
Bourbon	20-150'			"	
Culver	10-135'			"	
Ayr	40-100'			"	
Burr Oak	30- 90'			"	
Donaldson	15- 80'			"	
Harris Sta.	15- 30'			"	
Maxinkuckee	80-140'			"	
Inwood	12- 85'			"	
Lapaz	40- 50'			"	
Rutland	20- 50'			"	
Teegarden	35- 50'			"	
Tippecanoe	20- 40'			"	
Tyner	15-145'			"	
Walnut	15- 25'			"	

MINERAL ANALYSES OF WATERS FROM MARSHALL COUNTY
(Parts per million)

Location	Geological Condition	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate Radicle	Chlorine	Nitrite radicle	Nitrite radicle	Color	Total solids
Argos	Gravel		1.6		83	28				332		14	1.	.02	9	272
Bourbon	"		1.6		65	26				306		12	.5	.001	4	354
Bremen	"		1		139	18				161	16	13	6		9	314
Bremen	"		.2		116	27				289	42	30	6		19	582
Burr Oak	"		.01		119	25				379	103	30	6	.001	2	554
Culver	"		.3		113	25				286	8.6	2	.3	.001	52	252
Culver	"		.1		74	28				268	17	2	.1	.001	33	294
Culver	"		.01		88	29				301	20	10	4	.001	2	408
Donaldson	"		.2		65	25				245	25	9	.01	.001	9	306
Hibberd	"		.8		78	31				310	70	12	1		4	404
Inwood	"		.01		114	32				360	37	52	8	.001	2	644
Lapaz	"				89	43				331	62	33	1.2	.001		488
County House	"				85	32				302	36	8	.2	.001	2	396
Maxinkuckee	"		.2		69	25				268	6.6	1	.2	.06	19	344
Plymouth	"		.2		68	24				301	21	5		.001	4	278
Plymouth	"		2.		61	27	9	.1	169		Tr.	1.3				
Plymouth	"	21	.4		37	23	1	7.		242	2.3	1.5	.8			207
Plymouth	"	18	3.8		61	30	7	4.		326	3.6	.2	1.5			285
Teegarden	"				98	41				398	17	9.	.01	.001		394
Tyner	"				111	35				336	78	32	18		9	586
Walnut	"		.01		150	41				418	95	21	3.5	.001	2	720

M A R T I N C O U N T Y

GENERAL FEATURES

Area 339 square miles Population 10,103 (Census of 1930)

Martin County is located in the southwestern portion of the State; the third county from the Illinois-Indiana State line and the third county north of the Kentucky-Indiana State line. Shoals is the county seat.

The maximum altitude of Martin County is 860 feet above sea level and the minimum altitude is 425 feet, thus giving a total maximum relief of 435 feet. The maximum local relief is 300 feet.

Martin County is located within the driftless area of southern Indiana with the exception of a very narrow strip of land extending the entire length of the county, situated on the western margin. This strip of glaciated territory extends from a few rods to about two miles from the western boundary of the county and includes perhaps forty square miles of the county. The unglaciated surface of Martin County is included in the Crawford Upland physiographic unit. It is marked by the diversity of topographical forms and relief, which are due to a combination of influences, chiefly those of erosion and rock resistance.

The narrow strip of glaciated surface in the county is included in the Wabash Lowland physiographic unit. It is characterized at the contact with the Crawford Upland by glacial effects and aggradation. In the southwestern and northwestern corners of the county glacial lakes were in existence due to the ponding effect of the Illinoian glacier.

Drainage. -- Except for a small area in the northwestern part of the county which falls within the drainage basin of the West Fork of White River, all of Martin County lies within the drainage area of the East Fork of White River. This stream enters the county about eight miles south of the northeast corner of the county and pursues a winding course through the county to the south line where it forms the boundary for the southwest corner of the county.

The northeastern portion of the county is drained by Indian Creek and its tributaries. First Creek drains the extreme northwest part of the county. Boggs Creek rises south of the latter and flows south into White to drain the western part of the county. Turkey Creek is a northeastern branch of Boggs and Friends Creek a western branch. Lost River is an eastern branch of White River. Lost River has a small southern tributary, known as Blue Creek.

GEOLOGY

The unconsolidated deposits of Martin County consist of alluvial deposits along the East Fork of White River and glacia deposits on the western margin of the county.

The bedrock formations of Martin County consist of strata of the Mississippian and Pennsylvanian systems. Outcrops of the Chester series of the Mississippian system occur in the eastern part of the county and extend downstream to the westward on the westward flowing streams. The Pottsville series of the Pennsylvanian system of rocks outcrops in the western half the county. The Pennsylvanian rocks occupy the higher ridges and divides in the eastern part of Martin County and extend even into Orange and Lawrence counties topping high hills.

Generalized Geologic Section for Martin County

Quaternary:	
Recent, -- sands, clays, and gravels.	0- 25'
Pleistocene, -- sands, clays, and gravels . . .	0- 80'
Pennsylvanian, sandstones, shales, and limestones. .	0-200'
Mississippian, limestones, sandstones, and shales. .	1090'
Devonian, shales, limestones (Not exposed)	146'
Silurian, limestones and sandstones (Not exposed). .	400'

Sources of Water Supply in Martin County

Surface water supplies may be obtained from springs and streams in Martin County. Surface waters may be impounded in t streams and on the water sheds. The East Fork of White River flows diagonally from the central-eastern boundary of the count to the southwestern corner. This same stream furnishes several towns with water farther upstream and could be utilized in Martin County if necessary.

Ground waters may be obtained from several stratigraphic horizons in Martin County. The alluvial deposits along stream are always sources of good water. The glacial drift of the county is limited in areal extent and therefore cannot be considered. Also the drift caps hills and ridges which have valleys cut lower than the drift level which have a tendency to drain rapidly.

The Pennsylvanian strata consists of sandstones and shales. The basal Pennsylvanian is known as the Mansfield in this area and consists of sandstone and conglomeratic sandstone. Springs sometimes are found at the contact between the Mansfield sandstone and the underlying Chester formations. The Chester formations are noted for the number and excellency of their springs. This formation outcrops in the eastern half of Martin County.

Logs of wells drilled in prospecting for oil and gas show ground water at or near the contact between the Harrodsburg limestone and the underlying Borden series. A well drilled in Section 11, Township 2 N., Range 4 West, reported water at 822 feet and also at 1,926 feet. The latter depth is believed to be in the Silurian or Richmond series of the Ordovician.

Water Supplies of Towns in Martin County

Shoals, -- (population 1. 128) Shoals reports a water supply from one well, 6 inches in diameter and drilled in 1916. The depth to water level is 68 feet and sand rock and gravels are the source of the supply. The report states that the water supply is "going bad" in answer to a query as to the taste of the water. The well is city owned.

Loogootee, -- (population 2.203) The city of Loogootee reports a water supply from three wells, producing from limestone. Bedrock was penetrated at 248 feet and the depth to water level is 100 feet. The water has some iron in it, otherwise the supply is satisfactory. The system is privately owned.

MINERAL ANALYSIS

Location--Ritter Springs, Sec. 14, T3N, R3W. Analysis made by W. Simonson.

	Parts per million	Grains per gallon
Silica	73.25	4.28
Aluminum sulphate	689	40.34
Ferrous sulphate	548	32.
Calcium sulphate	1,966.6	114.85
Magnesium sulphate	2,660.	115.34
Potassium sulphate	115.66	6.72
Sodium sulphate	330.5	19.3

M I A M I C O U N T Y

GENERAL FEATURES

rea 381 square miles Population 29,032 (Census of 1930)

Miami County is located in central northern Indiana, five ounties from the Ohio-Indiana State line and five from the llinois-Indiana State line, and the fourth south of the lichigan-Indiana State line.

The highest elevation in Miami County is 870 feet above sea evel and the lowest elevation is 610 feet, thus giving a total aximum relief of 260 feet. The maximum local relief is 100 feet.

The Wabash River crosses the county from east to west in bout the center of the county and the surface slopes from both he north and south portions of the county toward the Wabash alley.

Miami County is well drained by the Wabash River and its ranches. The Mississinewa River enters the county from the east nd joins the Wabash River above Peru. The valley of the lississinewa is entrenched and rock outcrops are frequent. Big ipe Creek, another northwesterly flowing branch of the Wabash rains the south-central and southeastern parts of the county. eer Creek, another branch of the Wabash drains the southwestern art of the county. Eel River crosses the county in a diagonal ine near the north central part of the county. This stream has wo northern branches, Wessal Creek in the west and Squirrel reek in the east.

The northern portion of Miami county is occupied by morainal eposits. Eel River drains the moraines and it is conspicuous hat lakes are absent in the county. The Wabash River valley is illed with deposits of valley alluvium. Between Eel River and he Wabash River is an area of till plain, also in the east and outheast portions of the county till plain occurs. The Wabash uts its present channel through the till after its deposition nd of course is postglacial. The valley of the Wabash River is a great sluiceway which came into existence during the closing tages of the glacial period.

GEOLOGY

The bedrock formations of Miami County are composed largely of strata of Silurian age. Devonian limestone overlie the Silurian in small areas in the western part of the ounty. Along Pipe Creek, one mile northeast of Bunker Hill,

the Devonian rests on the Liston Creek limestone, indicating that the very upper Silurian formations have disappeared. The extreme upper Silurian formation, namely the Kokomo outcrops again west of Peru and overlies the Mississinewa shale. Along the south side of the Wabash River between Federal Highway 31 and the Miami Cass County line, the Kokomo limestone outcrops frequently in the channels of the tributary streams. For a complete description of the geology of these scattered outcrops one is referred to Publication No. 75, Department of Conservation, State of Indiana, "The Geology of the Silurian Rocks of Northern Indiana", 1928, by Cumings and Shrock. These authors show on a map that the extreme southwestern corner of Miami County is underlain by the Kenneth limestone of Devonian age. There are several rock outcrops along the Wabash River and the tributary rivers which consist of reefs in the Liston Creek limestone (Silurian). In the vicinity of Peru are located several such reefs.

General Geologic Section for Miami County

Recent, sands, clays, and gravels.	0- 50'
Pleistocene sands, clays and gravels	0-324'
Devonian limestone	0- 50' ?
Silurian limestones.	276-500'
Ordovician limestones and shales	400'
Ordovician limestone (Trenton)	42'

(Above determinations from well records)

From a structural geology standpoint Miami County is interesting in that it is located on the very northwesternmost extension of the Cincinnati Arch and that this county is located in the sag between the Cincinnati Arch influence and the effects of the Kankakee Arch to the northwest.

The unconsolidated deposits of Miami County are important aquifers. The alluvial deposits along the river valleys, the morainal deposits and the till beds all contain ground water. The till is less than 100 feet in thickness south of the Wabash Valley though is much thicker north of the Wabash Valley.

Sources of Water Supply in Miami County

Surface water supplies are available in Miami County from springs and streams. Many of the streams crossing the county are fed by lakes and springs and the supply of water is continuous. The impounding of water in the stream valleys and on the water sheds is also possible.

Ground water supplies exist in many of the formations underlying Miami County.

Water may be expected in the following formations:
Recent sands and gravels.
Pleistocene sands and gravels.
Devonian limestones.
Silurian limestones.
Ordovician limestones.

Potable waters which are not highly mineralized may be obtained from the mantle rocks and often from the upper-most bedrock if the latter contains join crevices. At several localities in the county potable water is secured from the Silurian limestones immediately underlying the glacial drift. At one time the city of Peru had a certain amount of salt in the water from the Silurian limestones, however, this was explained by the fact that in the development of the Trenton limestone oil-field at that locality, brines from the deeper oil-wells were permitted to contaminate the fresh waters occurring in higher horizons. This could have been avoided by properly casing the wells for oil and gas and by plugging in approved manner the wells as they were abandoned.

It has been observed in Northern Indiana that potable waters are found in the Silurian in most places where the Silurian immediately underlies the glacial drift.

A few artesian wells are reported in southeastern Miami County and along the Wabash River, and in creek valleys scattered throughout the county. West of Peru on the G. M. Tillett farm a well was drilled for gas. This well was artesian and the water came from the Niagaran (Silurian) limestone, which was 90 feet below the surface. When drilled into the Trenton the well showed salt water within four feet of the surface. Later when the casing was pulled the salt water was cut off. Limestone was penetrated at 44 feet in the well. The following log of this well is given in Water Supply Paper No. 254, p. 199:

Clay and gravel.	44'
Limestone.	420'
Shale.	425'
Trenton limestone.	12'
Total depth	901'

This well on the Tillett farm was known as the "Flowing Well" and produced as high as 600 gallons per minute for a long time.

In the city of Peru artesian waters come from the gravels and sands of the glacial drift. At Miami, artesian wells occur along the valley of Deer Creek. The limestone from which the waters come is reached at depths of 35-40 feet.

At Deedsville, in the northern part of the county, artesian wells at depths ranging from 30 to 60 feet in the gravels occur.

Peru. -- (population 12,730) Peru has a city water plant owned by the city. The supply is taken from four wells drilled within the last eight years and which penetrate limestone for the supply. It is 150 feet to bedrock at the wells and water occurs in the wells at depths ranging from 96 to 254 feet. Water rises to within eight feet of the curb of wells in the community. The city wells are ten inches in diameter and supply water of a good grade with a slight taste of lime and iron.

Converse. -- (population 931) Converse obtains a city water supply from one well eight inches in diameter and 240 feet deep. Bedrock is reported at 30 feet in depth at Converse, and the well penetrated 210 feet into limestone. The well is of the non-artesian type as water stands within six feet of the curb. Artesian wells are reported one mile north of Converse and others are about three miles north. The Converse water supply comes from the Silurian limestone.

Bunker Hill. -- (population 528) The town of Bunker Hill owns its public water supply. Tubular wells are the source of the water.

The following Miami County towns do not maintain public water supply systems.

Denver. -- (population 274)
Amboy. -- (population 483)
Ridgeview. -- (population 483)
North Grove. -- (population 119)
Macy. -- (population 279)

Typical Wells of Miami County

Location	Depth	Quality	Quantity	Formation	Construction
T29N-R3E					
Sec. 2	85'	Hard	Good	Gravel	Driven
Sec. 18	80'	"	"	"	Drilled
T29N-R4E					
Sec. 3	30-100'	"	"	"	"
Sec. 12	28- 30'	"	"	"	Driven
Sec. 15	64-100	"	"	"	Drilled
Sec. 34	175'	"	"	Limestone	"
T28N-R5E					
Sec. 4	135'	"	"	Gravel	"
T28N-R4E					
Sec. 2	40- 85'	"	"	"	"
Sec. 4	20- 70'	"	"	"	Driven & Drilld
T27N-R3E					
Sec. 6	50-115'	"	"	Limestone	Drilled
Sec. 18	20'	"	"	Gravel	Driven
T26N-R4E					
Sec. 8	20- 30'	"	"	"	"
Sec. 8	40'	"	"	Limestone	Drilled
Sec. 32	200'	"	"	"	"
Sec. 34	20-150'	"	"	Gravel	"
T25N-R4E					
Sec. 15	115-120'	"	"	Limestone	"
Sec. 35	100'	"	"	"	"
T25N-R5E					
Sec. 16	100'	"	"	"	"
Sec. 20	60'	"	"	"	"
Sec. 23	30- 40'	"	"	"	"

Location	Depth	Quality	Quantity	Formation	Construction
T26N-R5E Sec. 32	65-100'	Hard	Good	Gravel and limestone	Drilled
T27N-R4E Sec. 27	350'	"	Abundant	Limestone	"
T25N-R6E Sec. 36	50-240'	"	"	Gravel and limestone	Driven & drilled
T28N-R4E Sec. 21	10-100'	"	"	Gravel and limestone	" "
T26N-R4E Sec. 29	65- 85'	"	"	Limestone	Drilled
T25N-R5E Sec. 23	20- 45'	"	"	Limestone	"
T25N-R4E Sec. 30	15- 96'	"	"	Gravel & limestone	Dug, driven & drilled
T28N-R4E Sec. 13	18- 80'	"	"	Gravel	Dug, driven & drilled
T28N-R4E Sec. 34	20-110'	"	"	"	Dug, driven & drilled.
T29N-R4E Sec. 32	10- 65'	"	"	"	Dug, driven & drilled
T25N-R4E Sec. 3	20-120'	"	"	"	Dug, driven & drilled
T29N-R4E Sec. 18	20-230'	"	"	"	Dug, driven & drilled
T25N-R4E Sec. 12	20-110'	"	"	"	Dug, driven & drilled
T25N-R4E Sec. 8	8-105'	"	"	Gravel & Limestone	Dug, driven & drilled
T26N-R4E Sec. 7	20-105'	"	"	Gravel & Limestone	Dug, driven & drilled
T25N-R5E Sec. 16	80- 90'	"	"	Limestone	Driven & Drilled
T28N-R3E Sec. 2	20-156'	"	"	Gravel	" "
T28N-R5E Sec. 8	40- 75'	"	"	"	" "
T26N-R5E Sec. 10	60-205'	"	"	Gravel & limestone	" "
T26N-R5E Sec. 32	15-110'	"	"	Gravel & limestone	Dug, driven & drilled

Location	Depth	Quality	Quantity	Formation	Construction
T29N-R3E					
Sec. 2	15-170'	Hard	Abundant	Gravel	Dug, driven, & drilled
T25N-R4E					
Sec. 35	100-130'	"	"	Limestone	Drilled
T27N-R4E					
Sec. 28	10-130'	"	"	Gravel & limestone	Dug, driven, & drilled
Peru	350'			Limestone	Wabash River a wells
Converse	240'			"	
	30'			Gravel	
Denver	10- 60'			"	
	45-100'			Limestone	
Bunker Hill					
	65- 85'			"	
Amboy	20- 45'			"	
Bennetts Switch					
	15- 70'			Gravel	
	70- 96'			Limestone	
Chili	18- 80'			Gravel	
Courter	20-110'			"	
Deedsville	10- 65'			"	
Loree	20- 80'			"	
	80-120'			Limestone	
Macy	20-230'			Gravel	
McGrewsville					
	20-100			Gravel-Limestone at 110'	
Miami	8- 36'			Gravel	
	36-105			Limestone	
Nead	30- 85'			Gravel	
	85-105'			Limestone	
North Grove					
	80-100'			"	
Perrysville					
	20-156'			Gravel	
Pettysville					
	40- 75'			"	
Reserve	20- 60'			"	
	60-205			Limestone	
Santa Fe	15- 80'			Gravel	
	80-110'			Limestone	
Wagoner	15-170'			Gravel	
Wawpekong	100-130			Limestone	
West Peru	10- 20'			Gravel	
	25-130'			Limestone	

MINERAL ANALYSES OF WATERS FROM MIAMI COUNTY (132)

(Parts per million)

Location	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
Bunker Hill	23	3.2		71	37				370		5	.05	.04	4	562
Bunker Hill (3½ mi. west)	18	.01		66	38				375	8	6	.05	.001		428
Converse		.4		90	25				322	97	8	.05	.001	4	456
Deedsville		2		120	40				324	109	38	.1		9	596
Denver				86	27			6	218	68	10	.5			434
Macy		4		119	38				368	9	18	.05	.001	19	484
Macy		3.2		58					289		3	18	.001	19	252
Nead		.01		108	41				356	23	8	3	.003	9	406
Mexico		.04		86	27			14	222	23	9	8	.001	4	394
Miami		.1		104	34				297	9	3	9		5	352
Miami				83	28				200	145	45	3	4	8	466
North Grove		1.6		83	27				332	98	6	4	.04	6	422
Perrysburg		.12		71	22				177	47	21	.05		23	322
Peru				46	14	44		69		38	77	5.4			
Peru		3.2		69	21		3.2	137		28	2.8	6			
Peru				90	30	41		164		51	75	6.2			
Peru		2.8		91	34		9.6		350	76	2.2	Tr.			392
Peru		2.3		162	52	36	7.4		360	318	48	4.8			835
West Peru		1.4		134	38				316	53	84	.05	.001	50	360
Peru(5 mi.west)		.6		101	30				287	42	12	.1	.001	20	366
Pettysville		.1		85	25				226	24	2	8	.001	4	356
Reserve		.6		119	44				290	33	35	8	.01	4	434
Wagoner		4		109	31				336		1.5	.7	.001	60	288

MONROE COUNTY

GENERAL FEATURES

Area 416 square miles Population 35,974 (Census of 1930)

Monroe County is located in south-central Indiana, the third county from the Wabash River and the Illinois State line; and the fourth county north of the Ohio River which is the Indiana-Kentucky State line.

The maximum elevation in Monroe County is 1,006 feet and the minimum elevation is 490 feet, thus giving 516 feet of maximum relief. The maximum local relief is 400 feet.

Monroe County is largely located within the driftless area of southern Indiana, however, approximately 30 square miles in the northwestern corner were glaciated. Monroe County is almost the apex of the unglaciated area of southern Indiana, as the northernmost limits of the driftless area are in central-northern Monroe County and extend for a very short distance into Morgan County. Several old glacial lake remnants are noted in Monroe County, on the borders of the glacial margin and are due to ponding of glacial waters. The Flatwoods area, some six miles northwest from Ellettsville, and the Bean Blossom valley are the better known areas of ponding. Monroe County has a diversified topography, due to underlying rock structures.

The eastern part of the county is very rugged and the relief is conspicuous. It is included in the Norman Upland physiographic unit. The central portion of Monroe County consists of a more undulating and gentle plain developed on the Mississippian limestones with karst topography as a characteristic feature. The southwestern portion of the county is topographically rough and varied due to the character of the underlying Chester formations in a maturely dissected area.

Drainage. -- This county lies within the White River drainage basin. The West Fork of White River forms the boundary for a small part of the northwestern portion of the county. The principal tributary of the West Fork of White River in the northwestern part of the county is Bean Blossom Creek which flows west and northwest to enter the West Fork south of Gosport. This creek has a number of northern and southern branches. At the south is Big, Jack's Defeat, Walker, Cowden, Kirkem, Stouts, Griffy, Muddy Fork, and Shuffle creeks. Its branches flowing in from the north are Indian, Raccoon, Buck, Greasy and Honey creeks.

The northeastern part of the county is drained by Hackers Creek and Bryants Creek.

Salt Creek is formed in the southeastern part of the county by the union of Lick Fork and Muddy Fork. Salt Creek receives several tributaries including Clear Creek, Ramp Creek and Moores Creek.

The southwestern part of the county is drained by Indian Creek and its branches.

GEOLOGY

The unconsolidated deposits of Monroe County are of three types. One type is the alluvial deposits along the streams and the second type is the lacustrine-type of deposit in the glacial lake areas of the northern part of the county, associated with glacial border ponding. The third is the fans at bases of steep slopes.

Locally all types of deposits are important for water supplies, but their quantities are rather limited.

The bedrock formations of Monroe County consist of strata which belong to the Mississippian and Pennsylvanian systems. The eastern part of the county is underlain by rocks of Borden age, (Mississippian). The central, Mitchell plain portion of the County, has rocks of Mississippian age at and below the surface. These are largely limestones belonging to the Harrodsburg, Salem St. Louis, Ste. Genevieve formations. The southwestern portion of the county has Chester formations outcropping, also the basal Pennsylvanian or Pottsville sandstone caps several high hills.

General Geologic Section

Quaternary:

Recent, -- clays, sands and gravels	0- 20'
Pleistocene, -- sands, clays and gravels . . .	0- 80'
Pennsylvanian sandstones and clays	0-130'
Mississippian sandstones, shales and limestones . .	900'
Devonian limestones and shales	140'
Silurian limestones	240'
Ordovician limestones, sandstones and shales	1585'

(Above determinations made from well records).

Sources of Water Supply

Surface waters are obtained in Monroe County from springs, sinks and streams. Waters are also impounded for stock use on farms and for city supplies. The city of Bloomington has a reservoir situated four miles north of Bloomington on Griffy Creek and the Indiana University has a reservoir some two miles northeast of the city of Bloomington, located on a branch of Griffy Creek. A complete discussion of the Indiana University dam and water supply may be obtained by consulting an article by Dr. E.

Cumings, entitled, "The Geological Conditions of Municipal Water Supply in the Driftless Area of Southern Indiana," published in the Proceedings of the Indiana Academy of Science, 1911.

Dr. Cumings and other writers have stressed the fact that the Borden formation is ideal in many respects for the purposes of impounding water. The Indiana University supply and the supply for the city of Bloomington are held by dams located on Borden strata. Both reservoirs have given excellent service. The city of Bloomington has had a municipal water department for many years and the history of the various water supplies is illuminating in revealing the fact that competent advice and geological knowledge should have prevailed in locating the original supply and thus avoided the years of agitation and controversy.

Water may be obtained from sub-surface sources in Monroe County. The alluvial deposits along streams and steep slopes are locally of importance. The Borden formations are not considered aquifers as they hold tenaciously to the small quantities of water within their confines. Also the Borden strata are outcropping in regions of high relief and the formations are drained by deep valleys in many instances. Water is found at the top of the Borden, at the top of the Harrodsburg and at the top of the Salem formations and locally at certain horizons within the Chester series.

At many localities in Monroe County excellent springs occur at the contact of the Borden and Harrodsburg formations. These springs flow an abundance of good water and are never-failing even during seasons of greatest drought. It is believed that these waters follow crevices or joint cracks as many wells in Monroe County drilled down to and through these springs horizons fail to secure any appreciable flow of water.

Another spring horizon in Monroe County is at the contact between the Salem formation and the overlying St. Louis formation. Many of the springs appear to be in the St. Louis, a little above the contact mentioned. The Leonard and Shirley springs west of Bloomington in Section 24, Township 8 North, Range 2 West, flow from this horizon. At one time these springs supplied a reservoir with water which was pumped to the city of Bloomington and furnished a portion of the city supply. The St. Louis limestone is quite cavernous and this area is noted for the karst topography. Underground drainage dominates the entire region.

Another spring horizon in this area is at the contact between the Harrodsburg and the Salem limestones. The Ketcham's Sulphur Spring described in the 26th Annual Report of Indiana Department of Geology and Natural Resources (page 88) is reported in a rift in the Harrodsburg limestone in the bed of Clear Creek.

Local Supplies

Bloomington. -- (population 18,227). Bloomington has its own water company which secures a supply of water from a dam on Griffy Creek, some four miles north of the city.

Stinesville. -- (population 310). The town of Stinesville has no public water supply.

Ellettsville. -- (population 767). The town of Ellettsville owns its water supply system. The water is obtained from wells some few miles northwest of the town, in old glacial Lake Flatwoods. This old lake was formed by glacial ponding and the lacustrine sediments should furnish an abundance of good water.

M O N T G O M E R Y C O U N T Y

GENERAL FEATURES

Area 501 square miles Population 26,980 (Census of 1930)

Montgomery County is located in west-central Indiana, the third county east of the Illinois-Indiana line.

The maximum altitude of Montgomery County is 900 feet above sea level and the minimum altitude is 550 feet, thus giving a maximum relief of 350 feet. The maximum local relief is 180 feet.

The county is located within the Tipton Till Plain area of the State and was covered by both glacial invasions. The topography, which varies from level to rolling and hilly, is characteristic of a glacial region. The morainic belts are quite prominent in the northwestern portion of the county and assume a more gentle expression in the eastern and northeastern parts of the county. One morainic belt extends from the northwestern corner of the county to the southeastern corner of the county. This same belt is joined near Yountsville by a moraine which enters Montgomery County near the southwestern corner. Still a third morainic belt trends northwest-southeast across the county from near Linden to near Darlington. This belt of moraine is broken and dissected leaving morainal remnants.

Drainage. -- The drainage of Montgomery County is controlled largely by Sugar Creek which crosses the county diagonally from a point about five miles south of the northeastern corner of the county to a little more than five miles north of the southwestern corner of the county.

Branches of Sugar Creek which come from the north are Big Lye Creek, formed by the union of Old Slough and Potato Creek and Black Creek. From the south it receives Hazel Creek, Walnut with its two branches, North Fork and South Fork, Rattlesnake Creek with Offield branch and Indian Creek.

The northwestern part of the county is drained by Coal Creek which drains directly into the Wabash. Big Raccoon Creek and its branches, Cornstalk Creek and Haw Creek drain the southeastern corner of the county. Little Raccoon Creek drains a part of the southwestern corner of the county.

GEOLOGY

The unconsolidated deposits of Montgomery County consist of glacial drift, valley alluvium and outwash alluvial deposits. The drift in the county varies in thickness. In the northern part of the county wells are obtained at depths from 15 to 30 feet in beds of sand or gravel below the yellow till. It is not necessary to drill so much as 50 feet in many wells. Leverett in Water-Supply Paper No. 26, calls attention to a well drilled at Pleasant Hill, in the northwestern corner

of the county, 47 feet in depth, which penetrated a soft till for 37 feet, beneath which a much harder till was encountered. Along the morainic belts it is often necessary to drill deeper to strike better water horizons. Leverett gives the following log of a well drilled at Crawfordsville Junction:

Yellow till	12 feet
Soft blue till	60 "
Hard blue till with gravelly beds	64 "
Gravel	4 "
Total . . .	140 "

Several borings reveal the fact that old river valleys are present within the county as the drift is very thick in certain spots and just a few rods away bedrock will be found at comparatively shallow depths. Leverett calls attention to an attempted boring in Section 33, near Crawfordsville which penetrated 50 feet of till, and then entered a bed of quicksand, which continued at least to a depth of 240 feet, where the well was abandoned.

The alluvial deposits within the county occur along the streams and several alluvial fans are located at the bases of steep slopes.

"From its point of entrance into Montgomery County to about two miles below Yountsville, Sugar Creek has a valley of considerable width consisting of bottom or overflow land and terraces at varying elevations. Below this point the valley is contracted by precipitous bluffs, many of which are bare rocky cliffs from 100 to 200 feet or more in height. Numerous springs give rise to streams which have reduced the country for nearly a mile on either side of Sugar Creek to a net work of deep gullies and steep slopes, for the most part unsuited for cultivation."(133)

(133) Jones and Orahood, Report of Indiana Dept. of Geology and Natural Resources, 1912, p. 142.

The bedrock formations of Montgomery County consist of strata of Mississippian age except a small area in the very southwestern part of the county adjacent to Sugar Creek where Pennsylvanian strata are found. The bedrock formations were deeply eroded before the deposition of the glacial drift which accounts for the varying thicknesses of the drift.

The Mississippian formations of the county consist of the Borden series and small areas underlain by the Harrodsburg rocks in the southwestern part of the county. The Pottsville subdivision of the Pennsylvanian is recognized.

General Geologic Section

Quaternary:

Recent, -- sand, clays and gravels	0- 30'
Pleistocene, -- sands, clays and gravels . . .	0-140'

Pennsylvanian sandstones and shales	100'
Mississippian limestones, shales and sandstones	800'
Devonian shales and limestones.	150'
Silurian limestones	380'
Ordovician:	
Cincinnatian, -- shales and limestones. .	365'
Trenton, -- limestone	69'+

(Above determinations from well records.)

The upper surface of the Trenton limestone lies at an elevation of approximately 500 feet below sea level in the northeastern corner of the county and descends to an elevation of about 1000 feet below sea level in the southwestern corner of the county.

Sources of Water Supply

Surface waters may be obtained in Montgomery County from springs and streams. These surface supplies may be augmented by impounding water in the stream courses or on the water sheds. The glacial drift of the county is underlain by Borden rocks for the most part and suitable dam foundations could be obtained in these strata.

The ground waters which occur in the glacial drift supply the county with water. Wells drilled into the Borden rocks are not strong and can be considered only as seep wells. The Pennsylvanian strata are not of sufficient distribution in this county to be considered as a source of supply. Also the inconsolidated deposits in the form of alluvial fans are not important sources of water supply. Springs are numerous throughout Montgomery County and are to be explained by the fact that the surface has been dissected by many streams which cut below the water table. Especially is this true of Sugar Creek and accounts for the many good springs along that stream.

A boring made in search of gas at Crawfordsville reported sulphur water at a depth of 750 feet and this same well reported water at 240 feet in the Borden.

The log and interpretation of the formations of a well drilled at Crawfordsville follow:

Drift	140 feet
Sub-Carboniferous rocks	410 "
Devonian shale	80 "
Corniferous limestones	55 "
Niagaran limestone	380 "
Ordovician (Cincinnatial series) .	365 "
Trenton limestone	69 "
Total depth.	1499 "
Trenton below sea level.	664 "

We do not have good records of wells drilled in Montgomery County, and cannot know definetly the exact types of water available in strata below the Mississippian, however, it is likely that the deeper waters will not be potable.

Local Supplies

Crawfordsville, -- (population 10,555) Crawfordsville is supplied water by the Northern Indiana Public Service Company. Natural springs are the chief source of supply.

Darlington. -- (population 690) Darlington is supplied with water by seven wells drilled into the underlying limesto Bedrock is reported at 30 feet and the water-level is 20 feet below the surface. Two of the wells are six inches in diameter. The town owns the supply.

Ladoga. -- (population 829) Ladoga is furnished water by two wells ten inches in diameter, drilled into the limesto The limestone is penetrated at a depth of 40 feet and water is reported to occur at 165 feet. The town owns the supply.

The following towns have no public water supplies:
New Market (population 330)
Waveland (population 542)
New Richmond (population 391)
Wingate (population 408)
Linden (population 541)
Alamo (population 163)
New Ross (population 350)
Waynetown (population 664)

MORGAN COUNTY

GENERAL FEATURES

Area 406 square miles Population 19,424 (Census of 1930)

Morgan County is located in south-central Indiana, the fifth county north of the Kentucky-Indiana State line and the fourth county east of the Indiana-Illinois State line.

The maximum altitude of Morgan County is 915 feet above sea level and the minimum altitude is 560 feet, thus giving a maximum relief of 355 feet. The maximum local relief is 275 feet.

Morgan County was covered by the Illinoian glacier, though the second glaciation covered only the northern and eastern parts of the county. Remanents of the Shelbyville morainic system extend from the central northern boundary of the county across the county southeastward. The topography of the county is varied. The northern third is level to rolling with distinct evidences of the more pronounced glaciation. The southern and central portions of the county are very rough and broken. In the central western part of the county is an area of about forty square miles known as the "Flats" which extends into Owen County and as the name indicates is fairly level. The broad valley of White River cut deeply into the glacial drift and underlying sedimentary rocks is the striking topographic feature of the county.

Morgan County lies entirely in the drainage basin of the White River with the exception of the extreme northwestern corner which is drained westwardly into Eel River. The West Fork of White River enters the county on the east about three miles below the northern boundary and flows in a general southwesterly direction to leave the county at the southwestern corner. White River receives from the east and south the following branches: Crooked Creek, Stotts Creek, Clear Creek, Indian Creek and Little Indian Creek. From the north it receives White Lick Creek, Sycamore Creek, Burkhets Creek, Fall Creek and Bryants Creek. In the northwestern part of the county Mud Creek flows into Mill Creek and the latter serves as a part of the county boundary and thence flows westward into Eel River.

GEOLOGY

The early, or Illinoian ice-sheet extended entirely across Morgan County, however, the drift laid down by this glacier was not thick. It contained silt and clay with gravels and sands being of lesser importance. It is believed that the Illinoian drift had little influence on the original drainage system of the area. South of the limits of the Wisconsin or later drift sheet, the bedrock formations are exposed in many places. The north and northeastern portions of the county are the areas mantled with Wisconsin

drift. The drift in many places is unweathered and boulders and gravels occur at the surface. White River is very wide, the greatest width at Paragon being nearly four miles. Indian Creek, flowing west across the southern part of the county, is characterized by a wide valley in which is found extensive areas of sand. Mr. J.B. Edmondson in the Annual Report of the Indiana Geological Survey (1911) calls attention to this feature and states further: "This feature is especially in evidence in the region south and east of Martinsville, where the sand occurs in high rounded hills skirting the valley and extending for more than a mile back from the present valley site, in the form of high, dune-like mounds." He suggests that this sand may have been deposited here by the Illinoian ice-sheet, which evidently rested for a long period against the high Knobstone (Borden) bluffs, rising for 200 feet above the Indian Creek on th south, or more, probably, it was transported to the present position by the waters of White River when that stream was a great glacial river, the sand being derived from the disintegrati Knobstone sandstone or from the glacial debris. He further states that the wind may have assisted in fashioning the sand int the high rounded mounds. The same formations are also found along the bluffs of White River valley along its entire course through the county.

The bedrock formations of Morgan County consist of strata of Devonian and of Mississippian age. A small area of the bedrock comprising some two to three square miles in the extreme northeastern corner of the county, north of the West Fork of White River is underlain by Devonian shales.

The Borden formations underlie the glacial drift and are exposed in many places and comprise for the most part the bedrock of the county. In the extreme western part of the county, west from Martinsville, are found rocks belonging to the Harrodsburg and Salem formations. These are limestones and are found along the strike of the formation in normal position.

The Borden series constitutes the most important bedrock formation of Morgan County. Stockdale (134) states that the

(134)Stockdale, P.B., P "The Borden (Knobstone) Rocks of Souther Indiana." Publication No. 98, Dept. of Conservation, State of Indiana, p. 62.

total thickness of the Borden at Martinsville, Indiana, is 670 f This information is from well logs and calculations from known stratigraphic horizons.

General Geologic Section for Morgan County.

Quaternary:	
Recent, -- clays, sands and gravels	0- 25'
Pleistocene,-- clays, sands and gravels	0- 70'
Mississippian: shales and limestones, siltstones. . .	0-800'?
Devonian: limestones, shales and sandstones	182'
Silurian: limestones and shales	240'

rdovician:
Cincinnatian, -- shales and limestones. . . 570'
Trenton, -- limestones. . . . . 51'+ ?
(Determined largely from well records.)

Sources of Water Supply

Surface water supplies may be obtained from springs and treams. The West Fork of White River which flows diagonally cross the county, Indian Creek, and many smaller streams carry n abundance of surface waters, which in many cases might be tilized for other than human consumption, or with proper filration and elutriation could be used for city supplies.

Ground water supplies may be obtained from some of the forations, in partisular the glacial drift and recent deposits. The orden formation is not an aquifer of commercial importance, and nly seep wells yielding small quantities of water are found herein.

Underlying the Borden series is found the Rockford limestone hich is thin and usually not considered an aquifer.

Porter's Cave, located in Section 33, and the west one-half f Section 34, Township 12 North, Range 2 West, located in northastern Owen County and western Morgan County, is developed in ocks near the contact between the Harrodsburg limestone and the nderlying upper member of the Borden series, named Edwardsville y Stockdale. (Publication No. 98, Department of Conservation, tate of Indiana, p. 76). This cave is described by A. R. ddington in the Proceedings of the Indiana Academy of Science or 1926 (Vol. 36). It is difficult to point out the exact ontact between these formations at this locality. An immense pring flows from the mouth of Porter's Cave. The underground onduit is developed along the joints in Harrodsburg limestone.

Well records show about 150 feet of Devonian black shale nderlying the Mississippian strata. This is not an aquifer. elow the shale occur the Devonian limestones and sandstones which arry water. At Martinsville, in 1887, wells sunk for natural gas enetrated a supply of alkaline-saline- sulphuretted water at epths ranging from 668 to 704 feet. The first well was drilled o a depth of 1470 feet, and later wells reported the top of the renton limestone at a depth of 1700 feet. Later wells reported o water from 700 feet to 1700 feet. The water is used in the everal sanitariums located in Martinsville and comes from the pper portion of the Silurian. These wells are described at length n the 26th Annual Report of the Indiana Department of Geology nd Natural Resources for 1901 (page 92).

The Ordovician strata have been penetrated by the drill in organ County in a single well insofar as our records show and o statement was left concerning the condition of the contained ater, however, it is believed to be salt water and unfit for omestic purposes.

Water Supplies of Towns in Morgan County

Mooresville. -- (population 1,910) The town of Mooresville is supplied water from a dug well, privately owned.

Brooklyn. -- (population 545) The town of Brooklyn has no public water supply.

Morgantown. -- (population 748) The town of Morgantown owns its water supply, obtained from one dug well.

Paragon. -- (population 366) Paragon has no public water supply.

Martinsville. -- (population 4,962) Martinsville has a municipal water Department which obtains water from two wells drilled into the gravels of White River valley. One 30 inch well was dug in 1911, the other which is 26 inches in diameter was dug in 1925. Water is reported to stand within 18 feet of the surface in these wells and the two wells are estimated to produce 1,000,000 gallons per day.

NEWTON COUNTY

GENERAL FEATURES

Area 405 square miles Population 9,841 (Census of 1930)

Newton County is located in northwestern Indiana, the second county south of Lake Michigan and adjacent to the State of Illinois.

The maximum elevation in Newton County is 770 feet above sea level and the minimum elevation is 620 feet, thus giving a maximum relief of 150 feet. The maximum local relief is only 60 feet.

A small area located south of a distinct beach line which runs east-west across Newton County just north of Kentland is included within the Tipton Till Plain physiographic unit. This is the junction between the till plain and the flat lacustrine plain. The remainder of Newton County is included in the Northern Moraine and Lake Section and within the Kankakee Lacustrine Section subdivision. The surface of the county for the most part is fairly level, however, is broken by a prominent moraine some five or six miles north of the Iroquois River which extends east-west across the county. Southward from the moraine occurs the plain traversed by the Iroquois River and northward from the moraine the surface slope is northward toward the Kankakee River. This region bordering the Kankakee River is swampy and is lacustral in its characteristics.

Drainage. -- This county lies within the Kankakee drainage basin. This stream forms the boundary for the northern part of the county. The Kankakee sends out a tributary from near the northwestern corner of the county, known as the Beaver Lake Ditch. Beaver Creek Ditch flows westward and empties into the Iroquois River in Illinois. These artificial ditches have modified the original drainage.

The east-central part of the county is drained by a branch of the Iroquois River which crosses the southern part of the county from east to west. Adler Creek drains the southern part of the county into the Iroquois River. Curtis Creek flows in a general southeasterly direction near the east central part of the county, joining the Iroquois in Jasper County.

GEOLOGY

The unconsolidated deposits of Newton County consist of glacial deposits of morainal material and till and of fluvio-glacial materials associated with lacustrine deposits. North of the Marseilles Moraine the soils are largely of lacustral origin as this entire area was a portion of old glacial Lake Kankakee. The Iroquois valley in the eastern half of the county

has an average width of one-eighth of a mile and second bottom ar developed. The remainder of the river is in a narrow valley. Along the Kankakee River is a strip of swamp land and south to th Marseilles moraine the topography is that of a low, marshy plain, broken by many hills and ridges of various elevations. The swamp and marshy areas indicate the beds of ancient lakes and the low sand ridges mark in many places the old shore lines.

The thickness of the Pleistocene deposits in Newton County varies from outcrops of bedrock to 150 feet of till. There have been many wells drilled throughout the county. Several were drilled in exploring for oil and gas, and their records give us information about the glacial mantle.

The bedrock formations of Newton County consist of strata of Devonian and of Silurian age. There are some rocks perhaps older at the surface in the quarry east of Kentland. Present opinion places them in the Ordovician. Also the southeastern corner of the county is believed to be underlain by Mississippian rocks.

General Geologic Section for Newton County

Quaternary:	
Recent, -- sands, clays and gravels.	0- 50'
Pleistocene, -- clays, sands and gravels	0-150'
Mississippian: Borden series siltstones and shales	
Devonian shales and limestone	0-145'
Silurian limestone.	305'
Ordovician:	
Cincinnatian, -- shales and limestones	510'
Trenton, -- limestone.	60'+

(Section made from well records.)

The surface of the Trenton limestone in the northeastern part of Newton County lies at an elevation of about 200 feet belo sea level. In the southern part of the county the same surface is approximately 350 feet below sea level, according to maps published by Logan. (135)

(135) Logan, W. N., "The Subsurface Strata of Indiana," publicatio No. 108, Dept. of Conservation, State of Indiana, 1931, p. 21.

Sources of Water Supply

Surface water supplies in Newton County are obtained from Springs, streams and lakes. Beaver Lake is in McClelland Townshi and Mud Lake is in Colfax Township.

Ground water supplies may be obtained from the Recent, Pleistocene, Devonian and Silurian limestones. It is believed that waters in the Ordovician strata would be too highly mineralized to be potable.

Water Supplies of Towns in Newton County

Morocco. -- (population 1,006) Morocco reports a city owned supply of water from three wells. One 400 foot well reports a production of 45 gallons per minute, another well 800 feet in depth reports a production of 85 gallons per minute. A third well drilled in 1921 is ten inches in diameter. Bedrock was found in this well at 120 feet and water stands within eight feet of the surface. The 400 foot well is probably finished in the Silurian limestone and the 800 foot well reaches the Cincinnatian series of the Ordovician.

Goodland. -- (population 978) Goodland reports a municipally-owned water supply from three wells drilled into the underlying limestone. The bedrock occurs at 21 feet below the surface and water is found just above bedrock. The three wells are ten-inch wells, drilled in 1914 and are reported to be fair producers, with the water having a slight sulphur taste. A few artesian wells are located some three miles northwest of Goodland.

Brook. -- (population 815) The town of Brook owns one well producing water from a depth of 130 feet and bedrock is reported at 101 feet. This would appear to be in the underlying Devonian shale. It is likely that they have made some error in reporting depths, or our present information is incorrect regarding the sub-surface strata at this point. It is not believed that any well drilled into the New Albany black shale could produce 360,000 gallons of water per day.

Mount Ayr.-- (population 216) The town of Mount Ayr has no public water supply.

Kentland. -- (population 1,355) Kentland owns a city supply of water from two wells. Bedrock was penetrated at 90 feet and the water level is 52 feet. The water-bearing rock is a white sugar sand, which is probably a Borden horizon, just below the glacial drift.

Typical Wells of Newton County

Location	Depth	Quality	Quantity	Formation	Construction
T31N-R9W					
Sec. 15	20'	Medium	Good	Sand	Driven
Sec. 23	25	"	"	"	"
T31N-R8W					
Sec. 9	25- 30	Hard	"	"	"
Sec. 27	18	Medium	"	"	"
T30N-R8W					
Sec. 26	16	"	"	"	"
T29N-R8W					
Sec. 2	85	Hard	"	Gravel	Drilled
Sec. 14	100-135	"	"	Limestone	"
T28N-R8W					
Sec. 3	100	"	"	"	"
Sec. 14	80	"	"	Gravel	"
T27N-R7W					
Sec. 2	150	"	"	"	"
Sec. 26	520	"	"	Limestone	"

NOBLE COUNTY

GENERAL FEATURES

rea 417 square miles Population 22,404 (Census of 1930)

Noble County is located in northeastern Indiana, the second ounty from the Michigan-Indiana State line and the second county est of the Ohio-Indiana State line. Albion is the county seat.

The highest point in Noble County is 1,025 feet above sea evel and the lowest point is 845 feet, thus giving a maximum elief of 180 feet. The maximum local relief is 90 feet.

The morainal topography is the most prominent surface eature existing in Noble County. No county in the State has a reater proportion of its area mantled with moraines of the erminal and interlobate types.

Mr. O. A. Billman of Ligonier has given considerable aluable information in regard to ground water conditions in this ounty.

Drainage. -- The surface waters of Noble County pass into any drainage systems. The northwestern and the northern parts f the county are drained by North Branch and South Branch of he Elkhart River which flows northwestward to enter the St. oseph River near Elkhart. The eastern and southeastern portion f the county is drained by Black Creek and Cedar Creek. A small ortion of the southern part of the county is drained by Blue iver, a part of the Eel River system.

Tippecanoe River heads in the lake of that name in the outhwestern part of the county. A portion of the western part f the county is drained by Salamon's Creek, a tributary of lkhart River.

GEOLOGY

The unconsolidated deposits of Noble County consist of lacial deposits. There are no important areas of valley lluvium in the county.

A series of great morainic belts cover much of the county nd accounts for the diversified surface of rolling hills and ummocks and many of the intervening depressions are occupied by akes. The morainal materials are fairly thick, however, the round moraine or till occupies the entire area of the county. ecords of wells throughout the county indicate that the drift hickness is variable. At Kendallville an old boring for gas ave a total thickness of 485 feet of drift. A log of a well rilled at Albion shows a total thickness of 375 feet of drift. well drilled near LaOtto logged a total of 230 feet of glacial rift. A well at Ligonier logged a total thickness of 169 feet

of drift.

The bedrock formation in Noble County are believed to be of Devonian and Mississippian age. Our information must of necessity come from well records and just a few wells have penetrated the bedrock. Wells at Albion and LaOtto log black shale just below the drift, which must be the New Albany black shale of Devonian age, hence we are justified in concluding that a normal section of Devorian shale would obtain from these two points and southwestward. The geology underlying the drift in northern Indiana is known in a general way, however, no claim is made that our present knowledge is the last word on the subject. The fact that the bedrock surface existing in Pleistocene time had been subjected to erosion plus the modifying influences of the glacial advances, would leave some room for doubt as to ordinarily normal conditions prevailing. The northern half of the county is underlain by strata of Mississippian age, and believed to correspond to the Borden series of southern Indiana.

General Geologic Section for Noble County

Quaternary:
- Recent, -- sands, clays and gravels. . . . . 0- 50'
- Pleistocene, -- sands, clays and gravels . . . .100-485'
- (BEDROCK DOES NOT OUTCROP.)

Mississippian; shales and sandstones. . . . . 0-200'
Devonian: shales, limestone and sandstone. . . . . .100-190'
Silurian: limestones and shales. . . . . 815'
Ordovician:
- Cincinnatian, -- shales and limestones . . . . . 535'
- Trenton, -- limestone. . . . . 14'

Sources of Water Supply

Surface water supplies may be obtained in Noble County from streams, springs and lakes.

Lakes constitute an important source of surface water supplies. There are many excellent lakes in Noble County, which indicates that the ground water-table is at or near the surface. Some of these lakes are located in the following townships. In Wayne Township are Tamarack Lake, Round Lake, and Long Lake. In Orange Township are Reservoir Lake, Sylvan Lake, a part of Tamarack Lake and a part of Sanford Lake. In Elkhart Township are Sanford Lake, Waldron Lake and a part of Diamond Lake. In Sparta Township is a part of Eagle Lake. In York Township are parts of Diamond and Eagle Lakes, Long Lake and a part of Mill Pond Lake. In Jefferson Township is Skinner Lake. In Washington Township is Smaller Lake. In Noble Township are Bear Lake, Muncie Lake, Tippecanoe Lake, and parts of Loon, Crockett and Mill Pond lakes. In Green Township, there are three small lakes

Ground waters are found in the glacial drift of Noble County. and we have no records that it is necessary to penetrate the bedrock. It is doubtful if the bedrock strata of Noble County will ever be utilized for their water content. The Mississippian strata are poor aquifers and where penetrated at South Bend in St. Joseph County, bore salt water. It is likely that this same condition would obtain at or within Noble County. The Devonian shales which occur just below the drift in the southern half of the county are not aquifers and at the best would furnish only a little seep water. The Devonian limestones contain ground water and the underlying Pendleton sandstone carries water, however, wells at South Bend logged salt water at these horizons. From the fact that the Devonian and Silurian rocks of southern Noble County occur within a distance of approximately 20 miles of the locality where these same formations are adjacent to the glacial drift, namely, in southern Whitley County, it is believed that fresh water should occur within them. At the locality of South Bend, these formations are many miles removed from the outcrop or glacial till-bedrock contact.

Deep horizons in the Ordovician strata are sure to carry mineralized waters and are not to be considered as sources of supply.

Water Supplies of Towns in Noble County

Albion. -- (population 1,108) Albion obtains a municipally-owned water supply from two wells drilled into the drift and which penetrated gravels. Water rose to within a very few feet of the surface. The wells were drilled in 1925 and are ten inch wells. They are estimated to produce 1,728,000 gallons of water per day.

Avilla. -- (population 559) The town of Avilla owns a supply of water from two wells drilled into coarse gravels. Water is reported at a depth of 90 feet and bedrock at 100 feet. The water from the wells has a slight taste of iron. Some artesian wells are reported in the general locality.

Kendallville. -- (population 5,439) Kendallville has a municipal water department which obtains water from 21 wells. The water comes from sands and gravels, depth not given, and the surface of the water is 19 feet below the ground surface. The water-table is believed to be slowly receding. The water at Kendallville is reported as hard with a slight taste of sulphur.

Wolcottville. -- (population 646) See Lagrange County report.

Ligonier. -- (population 2,064) Ligonier obtains a supply of water from eight wells drilled into the coarse gravels of the drift. Bedrock is reported at about 420 feet in this locality. The water-table is at 45 feet in the city wells, however, this varies from 12 to 60 feet in the general locality. Liogonier's water supply is municipally owned.

Cromwell. -- (population 371) The town of Cromwell owns its public water supply, which is obtained from tubular wells.

Every incorporated town and city in Noble County has a public water system.

Typical Wells of Noble County

Location	Depth	Quality	Quantity	Formation	Construction
T23N-R9E					
SE¼ Sec. 24	130'	Hard	Good	Gravel	Driven
NW¼ Sec. 25	25	"	"	"	"
NE¼ Sec. 27	96	"	"	"	"
T34N-R9E					
NW¼ Sec. 13	65	"	"	Gravel & sand	Drilled
SW¼ Sec. 7	48	"	"	Gravel	Driven
NE¼ Sec. 16	35	"	"	"	"
T34N-R8E					
NE¼ Sec. 10	50	"	"	"	"
T35N-R8E					
Sec. 22	110-120	"	"	"	Drilled
T35N-R9E					
SE¼ Sec. 18	40	"	"	"	Driven
SW¼ Sec. 25	35	"	"	"	Drilled
SW¼ Sec. 28	60	"	"	Gravel & sand	Driven
T35N-R10E					
SW¼ Sec. 9	30- 65	"	"	Gravel & sand	"
SE¼ Sec. 27	70-113	"	"	Gravel	Drilled
SW¼ Sec. 29	60- 80	"	"	Gravel & lime	"
T34N-R9E					
SE¼ Sec. 25	36	"	"	Gravel	
SE¼ Sec. 25	100	"	"	"	Flowing well
Sec. 34	68	"	"	Sand	School house springs
SW¼ Sec. 27	60	Soft	"	"	Springs
NW¼ Sec. 32	60	"	"	Gravel	
SW¼ Sec. 31	70	Iron	"	"	
NW¼ Sec. 33	102	Soft	"	"	Drilled
Sec. 33	101	"	"	"	Drilled
T34N-R8E					
Sec. 26	10	"	Fair	"	Driven
Sec. 23	14	"	"	"	Driven
T33N-R8E					
NW¼ Sec. 16	85	"	Good	"	Drilled

Location	Depth	Quality	Quantity	Formation	Construction
T33N-R8E					
Sec. 9	-	Soft	Good	Gravel	Spring
Sec. 24	30'	"	"	"	Driven
T33N-R9E					
NE¼ Sec. 28	140	"	"	"	Drilled
NW¼ Sec. 33	200	"	"	"	"
SE¼ Sec. 21	213	"	"	"	"
NW¼ Sec. 26	60	"	"	"	"
T33N-R10E					
Sec. 19	50	"	"	"	"
SW¼ Sec. 20	140	"	"	"	"
NE¼ Sec. 19	40	"	"	"	"
SW¼ Sec. 15	70	"	"	"	"
T33N-R11E					
NE¼ Sec. 5	140	"	"	"	Drilled--springs
SW¼ Sec. 32	195	"	"	"	Drilled
NW¼ Sec. 5	190	"	"	"	"
SE¼ Sec. 34	40	"	"	"	"
NE¼ Sec. 23	100	"	"	"	
Sec. 34	25	"	"	"	"

O H I O C O U N T Y

GENERAL FEATURES

Area 85 square miles Population 3,747 (Census of 1930)

Ohio County is located in southeastern Indiana, having the Ohio River and Kentucky for its eastern boundary, Switzerland County for the southern boundary and the Laughery River and Dearborn County for the northern boundary. Ohio County has the distinction of being the smallest county within Indiana.

The maximum altitude in Ohio County is 875 feet above sea level and the minimum altitude is 425 feet, thus giving a maximum relief of 450 feet. The maximum local relief is 400 feet.

Ohio County is included within the Dearborn Upland unit of physiography. The local topography is dependent upon the proximity to the Ohio River and the softness of the bedrock. The Ohio River is so close that the streams have short courses and steep gradients, with resulting deep gorges and long, high ridges.

Drainage. -- The eastern boundary of Ohio County is formed by the Ohio River. A branch of the Ohio, Laughery River forms the northern boundary of the county. Arnold Creek drains the southeastern part of the county. It flows through Rising Sun to enter the Ohio at Millersburg southeast of the town. South Fork and its branches drain the southcentral part of the county and Bear Creek the southwestern part.

GEOLOGY

The unconsolidated deposits of Ohio County consist of alluvial deposits along a few streams, glacial terraces along the Ohio River and a few patches of glacial drift on the high ridges. The "Big Bottoms" of the Ohio River are about one-quarter of a mile in width along the eastern margin of the county, but wider near Rising Sun to about one mile in width. The bottoms are alluvial in origin and are typical flood-plain deposits.

A series of two or more terraces exists along the Ohio River in this area. Rising Sun is located on the first terrace, some 30 feet above the water-level of the Ohio River. Still another terrace or remnant of such a terrace is found above the first terrace. These terraces are of glacial or fluvio-glacial origin.

The bedrock formations of Ohio County belong to the Ordovician system. The rocks consist chiefly of shales and limestones.

General Geological Section for Ohio County

Quaternary:
- Recent, -- sands, clays and gravel. . . . . 0- 25'
- Pleistocene, -- sands, clays and gravels. . . . . 0- 50'

Ordovician:
- Cincinnatian: shales and limestones. . . . . 300'
- Trenton limestone (Very little exposed) . . . . . 305'
- St. Peter sandstone (Not exposed) . . . . . 10+

Sources of Water Supply

Surface water supplies are abundant in the principal streams of Ohio County. Water from the Ohio River could be utilized if necessity demanded. Other supplies may be obtained from springs and by the impounding of water in streams and on water-sheds.

Ground water supplies may be secured in the county from the mantle rock and from the limestone beds immediately underlying the mantle rocks. The water in the limestone passes downward through joint crevices until it encounters an impervious shale and then flows along the upper surface of the impervious layer. This accounts for the many springs which are found in this area. Many of the deep canyons and gorges are cut below the water table and in cases of perched water-tables, the impervious underlying layer causes the water to seep to the margins and be discharged.

Cisterns are very frequent in southeastern Indiana. Ground water conditions are not especially favorable in this area.

Water Supplies of Towns in Ohio County

Rising Sun. -- (population 1,379) Rising Sun secures a water-supply from 2 wells drilled in 1927, into the gravels of the terrace on which the city is located. The depth of the water-level is reported from 60 to 100 feet. The water system is privately owned.

Typical Water Supplies of Ohio County

Township	Quality	Depth	Formation
Cases			
SE¼-12-3-2	----	----	Spring
NE¼-14-3-2	Soft	----	Cistern
NW¼-22-3-2	----	31'	----
Aberdeen	----	20-30	----
NE¼-20-3-2	----	21	Shale
NE¼-19-3-2	----	28	----
NW¼- 7-3-2	----	23	----
Pike			
NE¼-24-3-3	Soft	----	Cistern
Freedom	----	15-25	Cisterns
SE¼-11-3-3	----	18	----
SE¼-12-3-3	Soft	----	Cistern

Township	Quality	Depth	Formation
Randolph			
French -9-4N.-1W	Hard	120'	Gravel
NE¼-16-4-1	Soft	----	Cistern
SW¼-15-4-1	"	----	"
NE¼-22-4-1	"	----	"
NW¼-27-4-1	Hard	96, 106, 37, 74.	Limestone
NW¼-26-4-1	----	64	----
NE¼-35-4-1	Soft	----	Cistern
Rising Sun	Hard	60-90	Gravel
NE¼- 9-3-1	"	75	----
NE¼-19-3-1	"	22	Limestone
NW¼-20-3-1	"	16-18	----
SE¼- 5-3-1	Soft	----	Cistern
NE¼- 7-3-1	"	----	"
SW¼-18-4-1	----	14	----
NE¼-17-4-1	Soft	----	Cistern
Union			
SE¼-32-4-2	----	20	----
Milton	----	15-25	Cisterns
SW¼-22-4-2	----	14	----
Hartford	----	20-30	----

ORANGE COUNTY

GENERAL FEATURES

Area 407 square miles Population 17,459 (Census of 1930)

Orange County is located in the central southern part of the State, the second county north of the Ohio River and the State of Kentucky. Crawford County is located between Orange County and the Ohio River at the nearest point. Orange County is the fourth county east of the Illinois-Indiana State line.

The maximum altitude in Orange County is 925 feet above sea level and the minimum altitude is 455 feet, thus giving a maximum relief of 470 feet. The maximum local relief is 430 feet.

The northeastern quarter of Orange County is a part of the Mitchell Plain and the remainder of the county is included within the Crawford Upland. The Mitchell Plain area is a karst region composed of sinkhole depressions and knob-to-ridge-like divides. The local relief is not great and where incipient sinkholes are developing, as in northeastern Orange County, the surface is almost flat. Dr. C. A. Malott writes,

> "The Mitchell Plain is best developed and has its widest extension in the area between Salem and Orangeville in Washington and Orange Counties. Lost River is within this area. The upper part of Lost River flows over the inclined plain with little entrenchment, and is perched rather high above its potential local baselevel. In the vicinity southeast of Orleans the present stream disappears downward through the limestone at an elevation of 625 feet and comes out as a much enlarged stream some eight miles distant to the west, near Orangeville, at an elevation of 490 feet."

Three-fourths of Orange County is included within the Crawford Upland physiographic unit. This unit is characterized by the great variety of topographic forms and diversity of relief, which are explained by the erosion of alternating series of hard and soft rocks. The Ohio River is the major stream toward which the other streams are cutting. The Ohio is close by and topographic maturity has readily developed.

Drainage. -- Much of the drainage of the north and eastern parts of Orange County is subterranean. Almost all of the drainage belongs to the Lost River system, which is a part of the East Fork of White River drainage. Lost River enters the county from the east and flows, partly at least, as a surface stream for a distance of about six miles. It then sinks to an underground channel to continue as a subterranean stream for a distance of seven or more miles, in a straight line. The underground stream receives contributions from a large number of streams which flow for short distances on the surface to ultimately sink through cavernous openings to underground channels.

Lost River rises to the surface some six or seven miles from the western border of the county and flows in a westerly direction to enter White River in southern Martin County. French Lick Creek Lick Creek and Stempers Creek are southern branches of Lost River A small branch of Blue River drains the extreme southeastern part of the county. The southern part is crossed by the Patoka River which has many small branches collecting surface waters in southe Orange County.

GEOLOGY

The unconsolidated deposits of Orange County do not enter into the consideration of ground water supplies, as the deposits are not of great extent. The only bottom soils to be considered are along Lost River, small areas in the meander curves, extending from Orangeville west to the county line. The Patoka River has a very narrow valley through the county but widens rapidly farther west.

The bedrock formations of Orange County consist of strata of Mississippian and Pennsylvanian age. The Mississippian rocks outcrop in the eastern and central portions of the county. The Pennsylvanian rocks outcrop in the western edges of the county and occupy irregular patches of over 25 square miles on the tops of the higher ridges.

The St. Louis and Ste. Genevieve limestone formations of the Mississippian system are the surface rocks in the northeastern and eastern portions of Orange County. The Karst features which are so wonderfully developed occur in these limestones. The underground disappearance of Lost River is related to the general karst feature development. Lost River flows for some seven miles measured in a straight line, underground. The actual course as outlined by the dry-bed channel is 21 miles. (For a more comple discussion of special features of Lost River, see Dr. C. A. Malott's paper "Lost River at Wesley Chapel Gulf, Orange County, Indiana." in the Proceedings of the Indiana Academy of Science for 1931 (1932), vol. 41, (pages 285-316).

The Chester formations outcrop in the western portion of Orange County and are overlain in several limited areas by the Pennsylvanian rocks.

Generalized Geologic Section for Orange County

Quaternary:	
Recent, -- residual and alluvial materials. . . .	0- 10'
Pennsylvanian:	
Pottsville, ...	100'±
Mississippian:	
Chester, --	310'
Ste. Genevieve, --	110'
St. Louis, --	170'
Salem, -- (Does not outcrop)	
Harrodsburg,-- (Does not outcrop)	
Borden group, -- (Does not outcrop)	
Rockford limestone, -- (Does not outcrop)	

Sources of Water Supply

Surface water supplies in Orange County may be obtained from springs and streams. Water may be obtained by impounding of surface waters in streams and on watersheds. In crossing the northern part of Orange County, one can see many solution sinks which have been filled with sediments so that the bottom outlet is clogged, thus permitting the sink to serve as a pond or small reservoir. These serve for the purpose of watering stock, and would not be depended upon for large supplies. It might be pointed out in this connection that city reservoirs constructed in the limestone area are not impervious and experience has proved that they are likely to leak. The city of Bloomington had considerable experience with a reservoir constructed under similar geological conditions.

The springs of Orange County are interesting. Lost River sinks and rises as an immense spring near Orangeville. The rise of Stampers Creek is another spring. These are springs of a special type.

At French Lick and West Baden are found the famous Mineral Springs, which have made this region famous as the Carlsbad of America. The springs issue from joints in the bedrock limestone, which are believed to be Paoli in age. It is known that the contact between the Chester formations and the Pennsylvanian formations is found at a higher level. One cannot say definitely that the mineral waters come from any certain formation, however, it is believed that they come from the St. Louis and Ste. Genevieve limestones. The chemical analyses of the waters show a high content of magnesium chloride and sodium sulphate. The two above mentioned Mississippian formations contain magnesium and pyrite from which a proper combination could be derived to give the mineral constituents which are found in the waters.

Water Supplies of Towns in Orange County

French Lick. -- (population 2,462) The French Lick town water supply is furnished from Lost River, by a privately owned company.

West Baden. -- (population 1,174) The town of West Baden is supplied water from Lost River by a privately owned company.

Orleans. -- (population 1,422) Orleans is supplied with water by the Interstate Public Service Company, a private corporation. The water is obtained from two wells. The depth to water level is given as 18 feet. The wells are shallow and the St. Louis limestone is the aquifer. Water running into caverns can be heard from the surface, so it is believed that subterranean drainage is in process of development here near the level of the water-table.

Paoli. -- (population 2,016) Paoli secures a water supply from Lick Creek. The town owns the city supply.

Typical Wells of Orange County

Township Section	Quality	Depth	Formation
North East			
SW¼ 23-3-1	Hard	90'	----
Leipsic	"	50- 60	----
SE¼ 19-3-2	"	62	----
SW¼ 20-3-2	"	58	----
Orleans			
Orleans	"	60- 80	----
NE¼ 30-3N-1E	"	95	----
SW¼ 21-3-1	"	112	----
NW¼ 22-3-1	"	97	----

O W E N C O U N T Y

GENERAL FEATURES

Area 393 square miles Population 11,351 (Census of 1930)

Owen County is located in west-central Indiana, the fifth county north of the Ohio River and the third county east of the Illinois-Indiana State line. Spencer is the county seat.

The maximum altitude of Owen County is 950 feet above sea level and the minimum altitude is 500 feet, thus giving a maximum relief of 450 feet. The average altitude is 700 feet above sea level and the maximum local relief is 300 feet.

All of Owen County with the exception of 16 to 20 square miles in the very southeastern corner has been glaciated. The Illinoian drift sheet covered the area, however, the later Wisconsin drift did not extend as far south as Owen County.

The topography of the county varies from a low, flat area in the northeastern part, comprising about one-eighth of the county, to a rolling upland in the southwest, and to a region which is exceedingly rough, including a strip of country six to ten miles wide extending in a southeasterly direction across the entire county.

Owen County lies wholly within the drainage basin of the West Fork of White River. White River crosses the southeastern part of the county and receives the waters of Raccoon Creek, an eastward branch, and of Mill, Rattlesnake and Fish Creeks, northern branches of White River.

Mill Creek, a branch of Eel River, flows through the northern part of the county and Jordan Creek and Six Mile Creek are other branches which flow westward into that stream and drain the northwestern part of the county. Eel River flows along the extreme southwestern corner and receives the waters of Lick Creek which drains that part of the county.

GEOLOGY

Owen County is very interesting geologically. The Illinoian ice sheet covered most of the county and left a thin mantle of drift. Due to the impounding of glacial waters to the northeast and to the subsequent escape of these waters the county is indebted in part for its hilly topography. Rocks belonging to the Mississippian and Pennsylvanian systems have been exposed in gorges and ravines throughout the county. Rocks of Mississippian age outcrop in the eastern half of the county and rocks of Pennsylvanian age outcrop in the western half. These Paleozoic formations were eroded deeply before the deposition of the glacial drift, thus explaining in part the varying thicknesses of the drift sheet.

General Geological Section for Owen County

Quaternary:	
Recent clays, -- sands and gravels.	0- 30'
Pleistocene, -- clays, sands and gravels.	0-100'
Pennsylvanian: shales and sandstones.	0-300'
Mississippian: shales, sandstones and limestones	880'
Devonian: shales and limestones (No outcrops)	200'
Silurian: limestones (No outcrops).	200'+

Sources of Water Supply

Surface waters in Owen County may be obtained from springs and streams. In this county are found hundreds of natural sprin Geologic conditions are correct for the occurrence of springs. Many water-bearing horizons are underlain by impervious layers o strata and then erosion has carved gorges and valleys down throu the entire layer, thus affording excellent conditions for the occurrence of natural springs. Also the rocks of Mississippian age, especially the upper Mississippian (Chester) rocks usually provide numerous springs.

Ground water is found in the recent sands and gravels along the major streams such as White River, and along Fish and Lick creeks. The streams in the southeastern part of the county are entrenched in deep, narrow valleys and are not streams which hav formed alluvial deposits along their courses.

The glacial deposits vary in thickness and in character. Some of the deposits are gravel and sand and some consist of til The thickness ranges from scarcely a trace in places to over 250 feet in some areas, the latter probably being preglacial valleys

Mention should be made of the character of Mississippian strata underlying parts of the county. The limestone formations lend themselves to the formation of caves and sub-terranean water conduits, and in many places underground streams burst from the hillsides as springs, or water flows from the mouth of a cave.

The Bordon series of the Mississippian outcropping north and east of Gosport is not a good aquifer, and if deep wells penetrate these strata in other portions of the county, difficul will be encountered in finding supplies of water.

The remaining Mississippian formations allow water to accumulate in joints and crevices and provide suitable water supplies where penetrated at such points.

In the western half of the county, in the outcrop area of the Pennsylvanian strata are found sandstones and coals belongin to the Pottsville subdivision. The Mansfield sandstone, basal member of the Pennsylvanian caps many high hills and affords

proper conditions for springs and ground water. Coal is found in the lower Pennsylvanian strata of the county.

Water Supplies of Towns in Owen County

Spencer. -- (population 2,179) Spencer is supplied water by the Wabash Valley Electric Company. The supply is obtained from two wells, eight inches in diameter, total depth unknown, but reported to be producing water from gravels. Water stands within 22 feet of the surface. Water is found at depths from 25 to 90 feet in the alluvial materials of the White River bottoms. The river is about 40 feet below the general level of the town and most wells find water at approximately this level. The drift at these wells is almost 100 feet in thickness.

The 18th Annual Report, Part IV, of the U. S. Geological Survey, (page 492) describes as follows some wells drilled at Spencer.

> "Three wells at this city have been sunk to the Niagara limestone for the purpose of obtaining the sulpho-saline water which it yields. The depth of each of the wells is about 1,150 feet. A salt water is found in the Subcarboniferous limestone at a depth of 450 feet, which is cased out in order to obtain the unmixed water from below. At one of these wells a large sanitarium has been built by Dr. E. V. Green, and an analysis of the water appears on a subsequent page. The capacity of the well at the level of the surface of the ground is about 200 gallons per minute, as it issues from a 4 inch casing. The head is sufficient to cause it to overflow from a pipe at a level 65 feet above the well mouth, or 625 feet above tide, and it apparently will rise much higher. A well made at the court-house supplies hydrants in the city, which are used extensively. The third well is on the Fletcher farm, about one-half mile northeast of the court-house."

This was published in 1897. The 26th Annual Report of the Indiana Department of Geology and Natural Resources (page 114) described these three wells and the uses to which they were put.

Gosport. -- (population 722) Gosport obtains a supply of water from two wells drilled into gravels along the White River bottoms. Water is reported to stand within 12 feet of the surface. Artesian wells are found near Gosport. One well drilled to a depth of 936 feet in 1895, produced a sulpho-saline water for several years from the Silurian limestone. The public supply is owned by the town.

PARKE COUNTY

GENERAL FEATURES

Area 447 square miles Population 16,561 (Census of 1930)

Parke County is located in west-central Indiana, the second county from the Illinois-Indiana State line. It is about equidistant from Michigan and Kentucky.

The maximum altitude of Parke County is 800 feet above sea level and the minimum is 455 feet above sea level, thus giving a maximum relief of 345 feet. The maximum local relief if 200 feet.

The county has a variety of surface features. The entire county was glaciated by the Illinoian glacier, however, the Wisconsin ice-sheet covered only the north half of the county. The southernmost boundary of the Wisconsin drift is marked by a terminal moraine, which extends from the southwestern corner of the county, northward along the Wabash River to the neighborhood of Montezuma and then swings abruptly eastward to leave the county about the center of the eastern boundary. Another morainal belt extends from just east of Montezuma northeastward to the southwestern corner of Montgomery County. The northern half of the county is included in the Tipton Till Plain area. The southeastern quarter of the county is included in the Crawford Upland physiographic unit, however, the glacial drift obscures further tracing of the unit northward. Considerable relief is found in the northeastern portion of Parke County along Sugar Creek, even though it has been glaciated. The southwestern quarter of the county is included with the Wabash Lowland, which is the area immediately adjacent to the Wabash River south of the outermost margin of the Wisconsin drift sheet.

Drainage. -- The drainage of Parke County belongs to the Wabash River System. In 1898 G. H. Ashley (136) wrote:

(136) Ashley, G. H., Parke County, in Coal Deposits of Indiana, 23rd. Annual Report, Indiana Department of Geology and Natural Resources, 1898. pp. 298-299.

"Parke County abounds in large streams. The Wabash River, flowing along the western border, receives in this county the waters of Coal Creek, Sugar Creek, and Raccoon Creek. The latter two streams rise well to the east of this area and carry an abundance of water. All along the eastern side of the Wabash, the bottom lands tend to have a width of one or two miles, back of which rise the bluffs from 100 to 250 feet high. Sugar Creek appears to be flowing through a post-glacial channel, as far as the mouth of Rush Creek, its immediate valley being usually narrow and often hemmed in by cliffs of sandstone, yielding many excellent exposures of the Coal Measure rocks, and affording some of the most

picturesque scenery of the State. Its principal tributaries from the north are Rush Creek and Sugar Mill Creek. The latter valley is somewhat of the type of Sugar Creek; the former is thought to have been possibly the pre-glacial channel of Sugar Creek, and its banks show little but glacial deposits of sand, clay and gravel. From the south side the principal tributary is Roaring Creek, which, in the lower part of its course, winds through a narrow, rocky ravine. Many of the smaller tributaries of Sugar Creek are, over the lower part of their courses, inclosed in rocky gorges with perpendicular or overhanging walls, these gorges being often from 50 to 100 feet deep and sometimes of a less width at the top than their depth, as at Turkey Run.

"Raccoon Creek and its principal tributary, Little Raccoon Creek, occupy their preglacial channels as far as Rosedale, above which point they have broad bottoms and yield but few exposures. These broad bottoms from Rosedale pass southwest into Vigo County, showing the former course of the stream. At present it turns northward at Rosedale and flows nearly parallel, though in an opposite direction, from the Wabash River, emptying into that river at the old mouth of Leatherwood Creek. This part of the channel is comparatively narrow and the side ravines yield numerous exposures, but it appears to have been a channel of some kind in preglacial times, judging from the fine deposits of gravel exposed along its banks. The principal tributaries are Leatherwood, Rocky Run, Iron Creek, Little Raccoon, with its tributaries, Wiesner Branch, Williams' Creek, and Sand Creek--Stronger's Branch, Rocky Fork, Troutman's Branch, and many smaller tributaries.

"As may be judged from the roads shown on the map, the surface of Parke County is much broken, especially in the eastern part, where the divides tend to become sharp-crested ridges. There are, however, all over the county, small, scattered patches of the level land so characteristic of the visit of the glacier."

GEOLOGY

The unconsolidated deposits of Parke County consist of stream and glacial deposits. The alluvial deposits occur along the Wabash River, Big Raccoon Creek, Sugar Creek, and Little Raccoon Creek. Glacial deposits in Parke County range from 25 to 150 feet in thickness. The southern part of the county mantled by the Illinoian drift does not have thick deposits. The remainder of the county was mantled by both drift sheets, however, the many streams of such great proportions have cut away the surface deposits or at least reduced their thicknesses. Where the termina moraines cross the county the drift is quite thick. Also the drif is very thick in preglacial stream channels.

The bedrock formations of Parke County consist of strata of he Pennsylvanian and Mississippian systems. The Mississippian trata occur along Raccoon Creek, along Sugar Creek and in the ortheast corner of the county in the neighborhood of Milligan. ost of the Mississippian rocks are exposed due to the downward utting action of streams, however, the northeastern corner of arke County is near the western margin of the natural outcrop of he Mississippian strata and glacial drift covers the bedrock.

General Geologic Section for Parke County

uaternary:	
Recent, -- sands, clays and gravels.	0- 40'
Pleistocene, -- sands, clays and gravels.	0-100'
ennsylvanian: shales, coals, sandstones and limestone	0-700'
ississippian: limestones, shales, siltstones.	730'?
evonian: shales, limestones, and sandstones (No outcrop)	276'?
ilurian: limestones (No outcrops)	268'
rdovician: limestones and shales (No outcrops). . . .	432'
rdovician: limestones (Trenton) (No outcrops)	10'

Sources of Water Supply in Parke County

Surface water supplies may be obtained in Parke County from springs and streams. Waters may be impounded on water-sheds along the courses of the streams. Springs are especially numerous throughout the county due to the deep trenching of the drift and upper bedrock formations by the streams.

The ground waters of Parke County occur in the Recent, Pleistocene, Pennsylvanian, Mississippian, Devonian, Silurian, and Ordovician strata. The wells drilled into the deeper strata show that waters from the Devonian and older strata are unfit for use. Blue lick water was found in Devonian strata in a well drilled in Reserve Township, Sec. 16, Twp. 16N, Range 8 West, 3 miles west of Bloomingdale on the Evans farm. The following is the log of this particular well:

Drift.	75'	Water enough for drilling.
Limestone.	95'	Water enough for drilling.
Dark shale	235'	
Oolitic limestone.	395'	Water
Shale.	700'	Water---12 bailers per hour.
Sandstone.	725'	
Light Shale.	775'	
Sandstone.	800'	Water, 5 bailers per hour.
Light shale.	875'	More water
Sandstone.	900'	
Shale.	930'	
Blue sandstone	960'	

Shale	1035'	
Black shale	1164'	Oil odor
Limestone	1200'	Blue lick water (Devonian)
Limestone	1280'	Water
Brown sandstone	1295'	
White limestone	1375'	Water
Hard lime and sandstone	1488'	Water
Niagaran limestone	1510'	

Surface elevation of this well is about 600 feet. Later this well was drilled to 2,300 feet, without finding oil or gas and then the well was plugged. We do not have the detailed log below 1,510 feet.

Water Supplies of Towns in Parke County

Rockville. -- (population 1,832) Rockville secures a supply of water from three wells drilled into the gravels. Water level is reported to be 28 feet. The wells were drilled in 1908, 1916, and 1922 and other wells in the community secure water at depths ranging from 25 to 28 feet. The town owns its water works.

Montezuma. -- (population 1,292) Montezuma owns its water supply obtained from two wells. Water is reported at 45 feet, occurring in gravels. The two city wells are eight and twelve inches in diameter and were drilled in 1925 and 1926. Montezuma is on the east bank of Wabash River so it is likely that the Wabash River gravels are the source of water supply, which assures the city of an abundance of good water.

One deep artesian sulphur-water well is of interest in Montezuma. The well was sunk in 1889 in search of gas to a depth of 1685 feet. Records show that at 298 feet, salt water occurred also salt water was penetrated at 450 feet. Each occurrence of salt water had sufficient head to rise to the surface. At 1220 feet, in a limestone immediately below the Devonian shales, the present flow of mineral water was developed.

The following towns do not have public water supply systems.

Bloomingdale. -- (population 412)
Judson. -- (population 111)
Rosedale. -- (population 657)
Marshall. -- (population 293)

PERRY COUNTY

GENERAL FEATURES

Area 384 square miles Population 16,625 (Census of 1930)

Perry County is located in the central portion of extreme southern Indiana on the Ohio River.

The maximum altitude in Perry County is 825 feet above sea level and the minimum altitude is 348 feet above sea level, thus giving a maximum relief of 477 feet. The maximun local relief is 325 feet.

It is included within the Crawford Upland area of the State. Dr. Malott (137) writes,

(137)Malott, C. A., Handbook of Indiana Geology, 1922, p. 101.

"Perry County has the distinction of being the roughest county in Indiana. Its condition is due both to its diversity of rocks, the most massive of which serve as ineffestive cap rocks, but make excellent bluff formers; and to its nearness to the deep gorge of the Ohio River, which with the similarly deep-set Anderson Creek on the west nearly surrounds the county, making the area a huge south-extending spur of upland in a highly dissected state. The only level land is found in the valleys."

Drainage. -- This county lies within the drainage system of the Ohio River which forms its southern boundary. The main tributary of the Ohio which enters the county is Anderson River which forms a portion of the western boundary of the county. Hurricane Fork is a northern branch of Anderson River which drains the northwestern part of the county. Middle Fork and Brush Fork are branches of Anderson River that assist in the drainage of the western part of the county. Oil Creek is a tributary of the Ohio which drains the northeastern part of the county. Poison Creek drains the southeastern part of the county and joins the Ohio.

Deer Creek and its branch, Little Deer Creek, drain the southern part of the county and the former enters the Ohio River.

GEOLOGY

The unconsolidated deposits of Perry County consist of alluvial deposits along the Ohio River and Anderson River. At most points along Perry County's southern boundary the Ohio River floodplain is on the Kentucky side of the river. In the big ox-bow to the north of Tobinsport, the valley flat is on the Indiana side. The first and second bottoms are sources of water supply, however, are not used to any great extent. The first bottoms are subject to inundation during high stages of the Ohio River and the second bottoms represent a river terrace.

Perry County is located within the driftless area of the State. The mantle of soil and surface rock is entirely residual. In the valleys deposition by streams is responsible for the flat areas. The county is maturely dissected.

The bedrock formations of Perry County consist of strata of the Mississippian and Pennsylvanian systems. The Mississippian rocks are found chiefly in the eastern half of the county and the Pennsylvanian outliers are found on high divides in the eastern portion of the county and some Mississippian inliers occur at lower elevations stratigraphically in the western part of the county. The general dip of the rocks is westward.

General Geologic Section for Perry County

Quaternary:

Recent,-- clay, sands and gravels	0-25'
Pleistocene, -- clays, sands and gravels	0-70'
Pennsylvanian: sandstones, clays, shales and coal	0-500'
Mississippian: limestones, sandstones and shales	800-1460
Devonian: shales and limestones (From well logs)	220'
Silurian: limestones (From well logs)	413'?

Record of Deep Well at Cannelton, Troy Township

Sand	47'
Shale	157'
White Sandstone	220'
Shale	229'
Limestone	270'
Shale	275'
Hard White Limestone	330'
Shale	346'
Limestone	352'
White sand	357'
Shale	360'
Sandstone	373'
Shale	396'
Black Limestone	406'
Gray Shale	436'
White lime	445'
Gray shale	460'
White shale, salt water	480'
Shale	518'
White limestone, salt water	733'
White limestone	736'
Limestone, salt water	774'
Limestone	940'
Dark sandy shale	1027'
Dark, brown limestone	1108'
Limestone	1680'
Shale	1800'
Limestone	2433'

The following are analyses of samples of river water and well water, Tell City, Indiana.

		(Grains per U. S. Gallon) River Water	Well Water
Temporary hardness	($CaCO_3$)	2.8	14.1
Permanent "	"	3.5	3.5
Total Dissolved Solids		9.8	23.8
Suspended Matter		2.2	.1
Calcium Bicarbonate		2.8	10.9
Magnesium Bicarbonate	($MgCO_3$)	nil	3.2
Calcium Sulphate	($CaSO_4$)	1.8	nil
Magnesium "	($MgSO_4$)	2.6	4.2
Sodium Sulphate	(Na_2SO_4)	nil	.6
Calcium Chloride	($CaCl_2$)	nil	nil
Magnesium Chloride	($MgCl_2$)	nil	nil
Sodium Chloride	($NaCl$)	1.5	2.5
Iron and Alumina	(R_2O_3)	.2	trace
Silica	(SiO_2)	.9	2.4

Sources of Water Supply

Surface water supplies may be obtained from springs and streams in Perry County. Water for stock supply is frequently impounded on the watersheds and along stream courses. The Chester formations of Upper Mississippian age which outcrop so abundantly in eastern Perry County are excellent spring horizons. The Chester formations have been deeply eroded by many streams which gives the proper setting for natural springs. The Beech Creek limestone, a subdivision of the Chester is perhaps the most noted spring horizon in Indiana. Many individual and private supplies of water, also town supplies are taken from springs issuing from the Beech Creek Limestone.

Water Supplies of Towns in Perry County

Cannelton. -- (population 2.265) Cannelton obtains a water-supply from 2 wells which are drilled into sand and gravels. Cannelton is located on the banks of the Ohio River and wells in that community get water at a depth of 40 feet. The water works is owned by the city.

Tell City.-- (population 4,873) The city of Tell City is supplied water by a privately owned water works. Three wells reported to prodeco from limestone are the source of the water. The water level is at 40 feet.

PIKE COUNTY

GENERAL FEATURES

Area 338 aquare miles Population 16,361 (Census of 1930)

Pike County is located in the southwestern part of the State. It is the second county east of the Wabash River and the State of Illinois. It is the second county north of the Ohio River and the State of Kentucky.

The maximum altitude of Pike County is 660 feet above sea level and the minimum altitude is 395 feet above sea level, thus giving a maximum relief of 265. The maximum local relief is 180 feet.

Pike County occupies an interesting position with respect to the deployment and distribution of the Illinoian glaciation. The boundary of the Illinoian glacier extends from northeastern Pike County in a southwesterwardly direction to leave the county in about the geographic position of the present exit of the Patoka River. North and west of this line the entire surface shows the results of the glaciation. The topography is fairly level to rolling. Along the northeastern part of the glacial boundary in this county, existed an old lake formed by the ponding influence of the ice and its load. This area known now as Lake Patoka extended east and southeast into Dubois county, with considerable areas in the latter county inundated. Also it is believed that a stream flowed across central Pike County from east to west, perhaps discharging from Lake Patoka. This old Lake Patoka country is a lake plain and occupies about twenty square miles in Pike County. The southern part of the county becomes very hilly and is typically non-glaciated with residual soil in restricted area, however, loess covers a large portion of the county from 5 to 10 feet in depth. Physiographically the county is included in the Wabash Lowland area.

Drainage.-- The surface waters of Pike County flow in part to the Ohio River and in part to the Wabash River. The larger part of the drainage is controlled by the Wabash through its branches, White River and Patoka River. White River forms the northwestern boundary of the county and has three short tributaries; Harbins Creek, Congers Creek and Pride Creek. The East Fork of White River forms the boundary of Pike County from the northeastern corner to about the center of the county, which is the junction with the West Fork of White River. The East Fork of White River has one tributary known as Mill Creek. The central part of the county is crossed from east to west by the Patoka River. Flat Creek, a branch of the Patoka drains the eastern part of the county. South Patoka and its branches, Weller Creek, Honey Creek, Rouge Creek and Log Creek drain the southwestern portion of the county. Cup Creek, a branch of the Patoka, drains the southeastern portion.

GEOLOGY

The unconsolidated deposits of Pike County consists of glacial debris, loess, flood-plain deposits, residual soil, and lacustrine deposits. West of Petersburg to the county line are found deposits of glacial till, exposed in part and also in part covered with loess. Small areas of terrace deposits are found al White River, west of Petersburg, also limited areas of dune sand. Residual soil is found in the southeastern part of the county in the hilly country and is derived from Pennsylvanian formations. The West Fork of White River, White River and the Patoka River have alluvial soils in the valley-flats. The Patoka is a very sluggish stream with wide bottoms and poor natural drainage. The lake deposits are found in the general region of Otwell where the old glacial lake existed.

The bedrock formations of Pike County consist of strata of Pennsylvanian age.

Generalized Geologic Section for Pike County

Quaternary:
Recent, -- . . . . . 0-20'
Pleistocene, --. . . . . 0-50'

Pennsylvanian: ---------- 900'
Post-Allegheny, -
Allegheny,-

Sources of Water Supply

Surface water supplies may be obtained in Pike County from springs and streams. Surface water may be collected and impounded on water-sheds and in the stream courses. Impermeable clays are generally available for the building of reservoirs.

Ground waters are obtained from a number of geological formations in Pike County. Water occurs in the glacial deposits in the northwestern part of the county and also in the flood-plain deposits along the rivers. There is little difficulty in securing water when the surface deposits of drift range from 20 to 60 feet in thickness. Also the contact between the drift and the bedrock is usually an excellent water-bearing horizon.

Potable water supplies are found in the bedrock strata of Pike County in the Pennsylvanian formations, which are outcropping or near the surface. Deeper horizons of Mississippian, Devonian and older strata are likely to be mineralized so that the waters will be unfit for use. Mineral water is often associated with certain coal horizons, however, in Pike County some of the coal strata bear potable water.

Frequently the upper beds of the Pennsylvanian are shaly and do not contain ground water. Individuals cannot offord to drill deeper wells and chance obtaining potable waters. Other supplies from reservoirs or streams, or cisterns must by utilized.

Water Supplies of Towns in Pike County

Spurgeon. -- (pooulation 375) The town of Spurgeon has no public water supply.

Winslow. -- (population 1175) Winslow owns its water system. The supply is obtained from the Patoka River.

Petersburg. -- (population 2,609) The city of Petersburg secures a water-supply from White River. The city owns the water works.

P O R T E R C O U N T Y

GENERAL FEATURES

ea 415 square miles Population 22,821 (Census of 1930)

Porter County is located in the northwestern corner of the ate, adjacent to Lake Michigan, and is the second county east the Illinois-Indiana line.

The maximum elevation of Porter County is 830 feet above a level and the minimum elevation is 581 feet above sea level, us giving a maximum relief of 249 feet. The maximum local lief is 190 feet.

Porter County has three main physiographic divisions; (1) e plain of glacial Lake Chicago or the Calumet Lacustrine ain, (2) the Valparaiso Morainic system and associated till ains, and (3) the outwash plain and lake plain of the Kanka- e Basin or perhaps better known as the Kankakee Lacustrine ction.

The Calumet Lacustrine Plain adjoins Lake Michigan. It is out 2 miles wide at the eastern boundary of the county, and miles wide where it crosses the western boundary of Porter unty. Low sand ridges parallel Lake Michigan and are remnants old beach lines which mark the successive stages of the sappearance of glacial Lake Chicago. The dune belt which tends northeastward from Gary, Indiana in Lake County, through rter County and into LaPorte County as far as Michigan City, the most prominent topographic feature. Mt. Tom north of esterton in Porter County rises 190 feet above the surface of ke Michigan.

The Valparaiso morainic system traverses the county in a rtheast and southwest direction. It has a width of about 10 les on the eastern county line and at the western margin of e county deploys into three prongs, with a total width of proximately 15 miles. At the city of Valparaiso the topography the typical knoll and sag type, hence the name to this morainic lt. This Valparaiso moraine is the divide between the St. wrence and the Mississippi drainage systems in northwestern diana.

"The topography of the Valparaiso Moraine and associated ound moraine is extremely varied. Much of it is fairly level gently undulating. A comparatively rough belt extends in a neral southwesterly direction from Burdick through Woodville nction and south of Sedley. It is most rugged southwest of odville Junction, where the hill slopes are often quite steep d gullied. This belt is marked by a general rise of over 100 et from the low land north of it to the higher land to the uth. In it are the headwaters of many small streams flowing

northward. There are some extensions of this broken belt into the higher and more nearly level land notably along the Baltimore & Ohio Railroad southeast of Woodville Junction, and along the Salt Creek Valley." (137)

(137) Barrett and Bushnell, Soil Survey of Porter County Indiana, U. S. Dept. of Agriculture, 1918.

The Kankakee Lacustine Section is very flat throughout. The general elevation of the flatter lands in the south end of Porter County is about 652 to 700 feet above sea level. The elevation of the Valparaiso Moraine is more than 800 feet in the higher part north and northeast of Valparaiso. At the summit in Section 30, Twp. 36, R. 5, the elevation is 888 feet. Lake Michigan is about 585 feet above sea level.

Mallott calls attention to the southeastern margin of the Valparaiso moraine as follows(138):

(138) Malott, C. A., Part II, Handbook of Indiana Geology, 1922, p. 116.

> "Flanking the outer margin of the Valparaiso moraine in middle eastern Porter County, and extending northeast through LaPort County into Michigan, is a great outwash apron which has an altitude of 775 to 800 feet at the margin of the moraine. It slopes southeast for 8 or 10 miles to the edge of the Kankakee marsh where it has an elevation of about 700 feet. This outwash apron constitutes an extensive gravel plain made by the drainage from the ice during the deposition of the Kalamazoo moraine. In places it is pitted. The drainage from the Valparaiso moraine passed through the broad valleys of Crooked and Mill Creeks chiefly. These valleys are somewhat trenched below the gravel plain."

The southeastern portion of Porter County is made up of the Kankakee Lacustrine Section which is very flat throughout. This area was naturally poorly drained, however, has been reclaimed by dredged ditches.

There is some swamp area along the Kankakee River, varying in width from a few rods to about two miles along the Lake-Porter County line. This area might be considered first bottom land of the Kankakee and has always been subjected to overflow and is permanently below the ground water table.

Drainage. -- The divide between the Lake Michigan drainage and the Kankakee drainage lies south of Valparaiso a few miles. The Kankakee River forms the southern boundary of Porter County and receives the drainage from the southern part of the county, south of the Valparaiso morainic belt. Hog Creek and Crooked Creek flow southward into the Kankakee and drain the southeastern part of the county. The south-central and southwestern parts of the county are drained by Sandy Hook Ditch, Wolf Creek Ditch, Hurl-hurt Ditch and Cobb Ditch. Coffee Creek and Salt Creek

are northward flowing branches of the Calumet River which flows from east to west across the northern end of Porter County. Sand Creek is a small stream flowing into Lake Michigan near Waverly Beach.

GEOLOGY

The unconsolidated deposits of Porter County consist of glacial drift, dune sands, old lake deposits and stream deposits made by existing streams. These deposits vary in thickness. The glacial drift ranges from 25 to 200 feet in thickness.

The bedrock of the county which immediately underlies the glacial drift is of Devonian age. Well records show that the drill goes from the drift into black shale which is Devonian. A few wells indicate the presence of some possible Mississippian formations immediately below the drift, however, if Mississippian rocks are found, it is believed that they are remnants occurring only in isolated patches.

General Geologic Section for Porter County
(Determined from well records)

Quaternary:	
Recent, -- clays and sands	0-100'
Pleistocene, -- clays, sands and gravels	100-300'
Devonian: shales and limestones	100-150'
Silurian: limestones	500-600'
Ordovician, shales and limestones	400-500'
Ordovician: (Trenton limestones)	144'

Still lower horizons are found and have been penetrated in a very few wells, however, our present knowledge of the pre-Trenton rocks is quite limited.

Sources of Water Supply in Porter County

Surface water supplies may be obtained in Porter County from springs, streams, and lakes. The largest supply of water is contained in Lake Michigan which forms the northern boundary of the county.

Two small lakes, Quinn and Eliza, are located in Porter Township. Hatch Lake, Flint Lake, Spectacle Lake, Kinney Lake, and a part of Long Lake are located in Center Township. Liberty Township contains Mill Pond, Moss Lake, Deep Lake, Walnut Lake, Mink Lake, Canada Lake, and Gunder's Lake. There are two small lakes in Jackson Township. Lake Longden's lies partly in Portage Township. These lakes are morainal in origin.

Ground waters are found in the surficial formations of Porter County and are contained in some of the bedrock formations.

The log of the following well is taken as a representative well for the county. This particular well was drilled by the San Juan Gas & Oil Company, and is known as the Arthur Hanrahan No. 1 well, located 300 feet from the west line and 300 feet from the north line of Section 36, Township 36 North, Range 6 west. Elevation at the surface is 865 feet.

Yellow clay	30'		
Blue shale, water	103'		
Shale	170'		
Blue shale, water	173'		
Sand	180'		
Shale	199'		
Lime	214'		
Shale	225'		
Small showing of gas	250'		
Brown shale	321'		
Hole full of sulphur water	328'	414'	
Salt water in Niagaran limestone	445'	Niagaran	Silurian
Sulphur water in Niagaran limestone	450'		
Sulphur water in Niagaran limestone	560'		
Sulphur water in Niagaran limestone	613'		
Sulphur water in Niagaran limestone	735'		
Brown lime	770'	340'	
White lime	820'		
Salt water	866'	Cincinnatian	
Shale	1077'		
Hole full of salt water	1145'	348'	Ordovician
Limestone	1314'	Trenton	
Trenton limestone	1325'	Limestone	
Sandstone	1332'	? St. Peter	

Sulphur and salt waters at comparatively shallow depths in the Silurian and Ordovician formations preclude the possibility of any further supplies from these and deeper horizons.

Location	Depth	Quality	Quantity	Formation	Construction
T36N-R5W					
Sec. 23	80'	Hard	Good	Sand and gravel	Driven
Sec. 19	123'	"	"	Gravel	"
T35N-R5W					
Sec. 7	80-150'	"	"	"	Drilled
T35N-R6W					
Sec. 16 NW¼	70- 80'	"	"	"	"
T35N-R7W					
Sec. 1	40- 60'	"	"	"	Driven
Sec. 14 NW¼	60'	"	"	"	"
T34N-R7W					
Sec. 1 NW¼	100'	"	"	"	Drilled

Typical Wells of Porter County.

Location	Depth	Quality	Quantity	Formation	Construction
T34N-R6W Sec. 16 SE¼	45'	Hard	Good	Gravel and sand	Drilled
T34N-R5W Sec. 25) Sec. 26) Sec. 27)	20'	"	"	Sand	Driven
Sec. 30 SE¼	30- 45'	"	"	"	Drilled
T33N-R5W Sec. 7 SW¼	18- 20'	"	"	Gravel	Driven
T33N-R7W Sec. 8 SW¼	40'	"	"	Sand	"
Sec. 10	70'	"	"	Gravel	Drilled

Water Supplies of Towns in Porter County

Hebron. -- (population 693) The town of Hebron owns its water supply, which is obtained from tubular wells.

Valparaiso. -- (population 8,079) The city of Valparaiso at one time received a water supply from Flint Lake, however, due to a lowering of the water table and the depletion of the supply, this source had to be abandoned. At present the city has its own water works which secures a supply of water from two wells. The water level is 52 feet in one well and 56 feet down from the surface in the other well. The water-bearing stratum is a very fine sand. From the location of the city on the Valparaiso Moraine and the presence of several lakes in that general area, it is believed that a sufficient supply of water should be obtained from the glacial drift. A very recent report of the State Board of Health indicates that the city supply is now obtained from Flint Lake. The information given in this report was in response to a questionnaire answered some two years ago.

Ogden Dunes. -- (population 50) The town of Ogden Dunes has no public water supply.

Chesterton. -- (population 2,231) Chesterton reports a water-supply from a single well, 18 inches in diameter. Bedrock is found at 55 feet and the water-table stands at a depth of 25 feet. The water-bearing horizon is fine sand. Lake Michigan has an altitude of about 585 feet above sea-level and Chesterton is given as 644.6 feet above sea level. This indicates that bedrock at Chesterton is about the same elevation as Lake Michigan level. The bedrock of the county dip northward. The town supply is privately owned.

Dune Acres. -- (population 12) Dune Acres reports one well, a concrete walled well 8 by 10 feet which secures an abundance of water from gravels. The water level is 20 feet below the surface. Artesian wells are reported from the Dunes State Park. The town of Dune Acres owns its water works.

Porter. -- (population 805) The town of Porter has no public water supply.

Kouts. -- (population 805) The town of Kouts has no public water supply.

P O S E Y C O U N T Y

GENERAL FEATURES

Area 402 square miles Population 17,853(Census of 1930)

Posey County is located in the extreme southwestern corner of Indiana. It is bounded on the west by the Wabash River, on the north by Gibson County, and on the south by the Ohio River and on the east by Vanderburgh County. It is the "Pocket" area of southwestern Indiana. The maximum altitude in Posey County is 585 feet above sea level and the minimum altitude is 313 feet above sea level, thus giving a maximum relief of 272 feet. The maximum local relief is 160 feet.

The location of Posey County at the confluence of two major streams is perhaps the controlling feature of its physiographic development plus the fact that non-resistant rocks outcrop in the area. The flood plains of these two rivers and the upland areas are the two main types of topography, however, the entire county is included in the Wabash Lowland area. The flood plains are level usually, with sloughs and low sand ridges breaking the monotony of the bottoms. Two or three terraces occur between the river course and the bluffs which separate the bottoms from the uplands. These terraces are known as first, second and third bottoms and are subject to flooding during high waters. The terraces were formed by erosion and aggradation during the successive stages of river history. The rise from the present river bottoms to the uplands is usually gentle, however, in some places where the Wabash River valley is narrow, the ascent is abrupt and bluff-like. The uplands of Posey County consist of low, rolling hills and broad valleys.

Drainage. -- The Wabash River bounds Posey County on the west. Black River and its principal tributary, Cox Creek, drain the northern part of the county. Their waters are discharged into the Wabash River. Gresham Creek and Rush Creek are small tributaries of the Wabash in the western part of the county.

The Ohio River bounds the county on the south. McFadden's Creek, drains a portion of the south part of the county into the Ohio River. Big Creek and its branches, South Fork and Macadoo Creek drain the central part of the county into the Wabash River.

GEOLOGY

The unconsolidated deposits of Posey County are of two general types; Those alluvial deposits formed by river aggradation and glacial deposits. The north part of the county was covered by the Illinoian glaciation which is bounded on the south, its outermost limit by a line extending entirely across

the county from southwest to northeast crossing through the county at the village of Oliver in a north sixty degrees east direction.

The bedrock formations of Posey County are composed of strata of the Pennsylvanian system of rocks. They consist of shales, shaly sandstones, impure limestones and coal beds.

General Geologic Section for Posey County

Quaternary:		
Recent, --sands, clays and gravels		0- 50'
Pleistocene, -- sands, clays and gravels . . .		0- 80'
Pennsylvanian:	sandstones, shales, limestone, coal	1000'±
Mississippian:	limestones, sandstones and shales .	978'±
	(Do not outcrop)	

A study of sub-surface records shows that the strata in the southern portion of Posey County dip toward the north and northwest. The Trenton formation is probably 4000 feet below sea-level in the southern part of the county.

SOURCES OF WATER SUPPLY

Surface water supplies may be obtained from streams, springs and lakes in Posey County. Two major streams, the Wabash and the Ohio form two of the county's boundaries. There are three lakes formed in abandoned channels of the Wabash and two formed in abandoned channels of the Ohio. Yellow Pond or Half Moon Pond and Hoveys Lakes are located in Point Township. Fish Lake or Pitchers Lake and another small lake are located in Black Township.

Artificial reservoirs for the collection of surface waters have been constructed at places on the water-sheds of the higher lands.

Ground waters may be obtained in Posey County from the river alluvial deposits, the glacial deposits and from the surface formations. The upper bedrock of Pennsylvanian age usually has potable waters, however, some wells in the county have found salt water even in the Pennsylvanian. The waters from rocks older than the Pennsylvanian system are in most cases mineralized and unfit for consumption. Some of the Chester formations of Upper Mississippian age are reported to carry fresh water in this county.

Water Supplies of Towns in Posey County

Griffin. -- (population 208) The town of Griffin has no public water system.

Mount Vernon. -- (population 5,035) Mount Vernon is supplied with water by the Southern Indiana Gas & Electric Company, a private corporation. The supply is taken from the

Ohio River.

New Harmony. --(population 1,022) New Harmony owns its water works. The supply is obtained from tubular wells.

Poseyville. -- (population 810) The town of Poseyville owns its water supply, obtained from one dug well.

Cynthiana . -- (population 556) Cynthiana has a new dug well, however, no data were secured in regard to the source of the water, but from the location of the town, the glacial drift is probably the horizon. The water system is owned by the town.

PULASKI COUNTY

GENERAL FEATURES

Area 432 square miles Population 11,195(Census of 1930)

Pulaski County is located in northwestern Indiana, the third county south of Michigan and Lake Michigan, and the third county east of the Illinois-Indiana State line.

The greatest elevation in the county above sea level is 750 feet and the lowest is 660 feet, thus giving a maximum relief of 90 feet. The maximum local relief is 45 feet. The average altitude of the county is 700 feet above sea level.

Pulaski County lies for the most part within the Tippecanoe drainage basin. Tippecanoe River enters the county near the northeastern corner and flows in a southwesterly direction through the county. Indian Creek is an important branch of the Tippecanoe, draining the southeastern part of the county. Mill Creek is an eastern branch of the Tippecanoe which drains an area in the eastern part of the county. The western part of the county is drained by Big Monon Creek and its tributary Little Monon Creek. A small area in the north-central part of the county is drained by a tributary of the Kankakee River.

Pulaski County is almost entirely covered with sand ridges and marshes. It is a portion of the Kankakee Lacustrine Section of the Northern Lake and Morainal Section physiographic unit as discussed by Dryer and Malott. The county at the close of the glacial epoch was covered with waters coming from a retreating flacier. The extreme northeastern corner of the county has a small area of morainal topography and in the eastern and southern margins of the county are found areas with till at the surface. Most of the immediate surface deposits are due to Recent weathering activities on Pleistocene lacustrine deposits.

GEOLOGY

The bedrock formations of Pulaski County consist of strata of Silurian and Devonian age. Underlying the glacial drift in the south half of the county occur rocks of Silurian age, while Devonian strata underlie the glacial drift in the north half of the county. With the exception of a few outcrops in the southwestern part of the county, the bedrock is concealed by the mantle of glacial drift which attains a thickness as great as 200 feet in places.

A single quarry in Niagaran (Silurian) strata is known in Pulaski County, and this quarry face is almost hidden by water. The quarry is located in the S.E. of S.W. $\frac{1}{4}$ Sec.14, T29N, R4W., two miles southeast of Francesville. According

to Cumings and Shrock the stone which is barely exposed around the edges of the small opening, is of Huntington age, very similar to that quarried at Monon, Indiana. The rock that was quarried here was crushed and used locally for road building in Pulaski County.

A general geological section for Pulaski County taken from logs of wells is as follows:

Quaternary:

Recent, -- Sands, clays
Pleistocene, -- Sands, gravels, clays
Shales (New Albany)

Devonian:- Limestones
Sandstone (Pendleton)

Silurian: -- Limestones (Niagaran)
Ordovician: -- Limestones, shales (Richmond)
Limestone (Trenton) Mohawkian

Older rocks must lie at still greater depths however they have not been penetrated by the drill.

The surface formations of the county consist of unconsolidated deposits of glacial origin and of lacustrine origin. They vary in thickness from 0 to 200 feet. It is believed that the drift is thickor in the eastern part of the county and thins westward.

SOURCES OF WATER SUPPLY

Surface water supplies may be obtained in Pulaski County from springs and streams. There are two small lakes in Harrison Township through which Mill Creek flows. Bruce Lake lies partly in the eastern part of Harrison Township.

Ground water supplies may be obtained from a number of geological sources. Abundant supplies of ground water are found in the mantle rock deposits of Pulaski County in nearly all parts of the county. The mantle rock is thin in a small area in the southwestern part of the county and supplies in this glacial covering are limited.

Near Francesville, water has been found quite near the surface in the Silurian strata. W. H. Thompson in the 16th Annual Report of the Indiana Department of Geology and Natural History describes an area a few miles northwest of Francesville where some men cleared away the surface soil to a depth of eight feet and found a natural spring in the Niagaran limestone This spring issued from a crevice in the rock and flowed with considerable volume. The Silurian strata immediately beneath the glacial drift or where they outcrop are usually excellent aquifers.

North of an east-west line extending through Medaryville, the New Albany shale of the Devonian occurs just below the glacial drift. The New Albany shale is a poor water-bearer.

South of the east-west line through the county extending through Medaryville occurs the sandstones and limestones of the Devonian below the drift. This belt should bear good water where penetrated, however it is of limited areal extent.

The water from the Trenton formation was salty and unfit for use.

Water Supplies of Towns in Pulaski County.

Winamac. -- (population 1,679). The town of Winamac owns its public water supply which is obtained from tubular wells.

Francesville. -- (popluation 712). The town of Francesville has no public water supply system, according to records published by the State Board of Health.

Monterey. -- (population 283). The town of Monterey has no public water supply system.

Medaryville. -- (population 610). Medaryville owns its water works. The supply is obtained from tubular wells.

Typical Wells of Pulaski County

Location	Depth	Quality	Quantity	Formation	Construction
T29N-R4W					
Sec. 9	115'	Hard	Good	Limestone	Drilled
T29N-R3W					
Sec. 7	30-40	Medium	"	Sand	Driven
Sec. 9	20-40	"	"	"	"
Sec.9-12	30	"	"	"	"
T29N-R1W					
Sec. 8	30	"	"	"	Drilled
Sec.11	35	"	"	"	"
T20N-R4W					
Sec. 4	80	Hard	"	Limestone	"
T29N-R2W					
Sec. 7	50-60	Medium	"	Sand	Driven
Sec. 9	125	"	"	"	"
Sec.10	20	"	"	"	"
T30N-R4W					
Sec. 4	68-70	"	"	Rock	Drilled--sulphur
T31N-R4W					
Sec.36	20	"	"	Sand	Driven
T30N-R2W					
Sec. 5	15-20	"	"	"	"

PUTNAM COUNTY

GENERAL FEATURES

Area 483 square miles Population 20,448(Census of 1930)

Putnam County is located west of Indianapolis in central-western Indiana. It contains all of townships 13, 14, 15 and 16 north of ranges 3, 4, and 5 west, the northern half of township 12 north of ranges 3, 4, and 5 west, small portions of townships 13 and 14 north of range 2 west.

The greatest elevation in Putnam County is 925 feet and the minimum is 580 feet above sea level. This gives a maximum relief of 345 feet, however, the maximum local relief is 180 feet. The surface of the land in the northeastern part of the county is fairly level, in the northern and northwestern portions the surface is gently undulating to rolling, however, many preglacial valleys have been filled with drift which averages 30 to 60 feet in thickness in this part of the county. The southern part of Putnam County is hilly and as only one drift sheet covered this southern half, the valleys are more conspicuous and the drift seldom exceeds 20 to 30 feet. Bedrock is exposed at many points throughout the county.

Putnam county lies for the most part in the Eel River drainage basin. The northwestern corner of the county is drained by branches of Little Raccoon and of Big Raccoon Creeks. Big Walnut Creek enters near the northeastern corner of the county and flows in a southwesterly direction to join with Mill Creek and form Eel River at a point about two miles north of the south county boundary and about three miles from the west boundary. Little Walnut Creek, a branch of Big Walnut drains an area in the western part of the county. Mill Creek and its branches drain the southeastern and southern portions of the county.

GEOLOGY

All of Putnam County was covered by the Illinoian glacial drift and the north half of the county was covered by the Wisconsin drift. This explains in part the fact that the southern portion of the county is more hilly and rougher topographically. Outcrops therefore are more abundant in the southern half of the county.

The bedrock which underlie Putnam County consist of strata of Mississippian and Pennsylvanian age. The eastern three-fourths of the county is underlain by rocks of Mississippian age and the western one-fourth by rock of Pennsylvanian age. The bedrock is concealed by glacial drift over large areas of the county.

A general geological section for the county follows:

Quaternary:
Recent, -- sands, and gravels
Pleistocene, -- Wisconsin and Illinoian glacial drift
Sandstones, shales, coal (Brazil)
Pennsylvanian: sandstone, coal, clay (Mansfield)

Mississippian: limestones, sandstones, shales (Chester
limestones (St. Genevieve and St. Louis)
limestones (Salem, Harrodsburg)
shales, siltstones, sandstones (Borden)
limestone (Rockford) (no outcrops)

Devonian: (not exposed)
shale (New Albany)
limestone (Sellersburg ? Jeffersonville ?)
sandstone (Pendleton?)

Silurian: (not exposed)
limestone (Huntington,? etc.)
shale

Ordovician: (not exposed)
limestone, shales (Richmond)
limestone, Mohawkian (Trenton)

The bedrocks of Putnam County dip to the southwest. The upper surface of the Trenton limestone in the northeastern part of the county lies about 600 feet below sea level and in the southwestern part of the county it lies about 1400 feet below sea level.

Sources of Water Supply

Surface water supplies in Putnam County may be obtained from springs and streams. Waters may be impounded by the construction of reservoirs on the water-sheds and in the courses of streams.

Ground waters may be obtained from a number of formations lying beneath the surface of the county. In the northern part of the county ground waters occur in the glacial drift. In the southern part the drift is not so thick and erosion has removed much of it, therefore the drift is not as dependable for a source of supply. In the valleys some water is obtained from the drift and on the ridges most of the wells go to bedrock for water. There are some springs along the valle but they are not an important source of supply.

The following geological formations of Putnam County contain water-bearing horizons:

Recent sand and gravels
Pleistocene sands and gravels

Pennsylvanian sandstones
Mississippian limestones and sandstones
Devonian limestones and sandstones
Silurian limestones
Ordovician limestones and sandstones.

One well drilled in Section 28, Russell Township found a strong flow of salt water at 800 feet. This was probably in Devonian limestones. At Reelsville, in Washington Township an artesian well found salt water at 1240 feet with the surface elevation at this point being 600 feet above sea level. This was drilled into the Silurian limestones. It is also known that the Trenton and St. Peter sandstone carry salt water, so it seems that the deeper horizons do not give promise of potable water.

The Mansfield sandstone, outcropping so abundantly in the western part of the county should be a good aquifer and locally springs and seeps occur along the outcrop.

Water Supplies of Towns in Putnam County

Greencastle. -- (population 4,613) Greencastle obtains water from a system owned by the Greencastle Waterworks Company a private corporation. The system has been in operation for 46 years. The water is obtained from perforated tile buried in the valley of Walnut Creek, north of Greencastle one mile. One string of tile extends on either side of the creek with a connecting string of tile beneath the water-bed of the creek. These two parallel systems of tile extend approximately 550 and 600 feet along the river banks. The tile vary from 12 to 20 inches in diameter. This system furnishes filtered water so it is only necessary to use a small amount of chlorine in order to put excellent water into the mains. The system is reported to be supplying Greencastle with 700,000 gallons of water per 24 hours.

Roachdale. --(population 631) Roachdale obtains a town supply of water from 1 well drilled into limestone at 30 feet. Water stands at 15 feet in the well and the well is reported to make 24,000 gallons per day. The supply is owned by the town.

R A N D O L P H C O U N T Y

GENERAL FEATURES

rea 447 square miles Population 24,859 (Census of 1930)

Randolph County is located in eastern central Indiana. Its astern boundary is the Indiana-Ohio State line. It is the sixth ounty south of the Indiana-Michigan State line. Winchester is he county seat.

Randolph County has the distinction of having the highest verage altitude of any county in the State. The maximum altitude s 1285 feet above sea level, the minimum is 915. The total aximum relief is 370 feet. The maximum local relief is 140 feet.

As a whole, the surface of the county is fairly level.

"A small moraine of less than a mile in width and ranging etween 25 and 50 feet in height enters the State at Union City nd follows the north bank of White River entirely across the ounty entering Delaware County a short distance north of Windsor." . E. Taylor (139) continues the description as follows:

139) Taylor, A. E. A Soil Survey of Randolph, Wayne, Henry, ush, Fayette, Union and Franklin Counties, 34th Annual Report, ndiana Department of Geology and Natural Resources, 1909. p. 48.

"The topography north of this ridge is a gently undulating lain sloping gradually to the south bank of the Mississinewa iver, which lies 6 miles north. This plain is dotted with umerous small shallow basins, which are now Miami black clay oam areas, but in the past were small lakelets, ponds, and arshes. North of the Mississinewa one again encounters a rather ronounced morainic area, extending from east to west across the orth end of the county. The strongest morainic belt is located n the southern tier of townships. It has a breadth of 5 or 6 iles and carries knolls and ridges varying from 30 to 50 feet n height. It is also the principal watershed and divide between hite and Whitewater Rivers. Martindale Creek and Green's Fork s known as the "Summit" with an altitude of 1,234.4 feet, which s the greatest measured in the State. Hills south of this point re estimated to be 50 feet higher. Between this heavy moraine nd White River is another almost level plain, with the frequent ccurrences of dark colored areas (Miami black clay loam) occupying depressions in the light colored soils.

"In the southern part of the county, where the surface is olling, these old kettle basins, occupied by the dark colored oil, are rare. This is not due to the basins never having been eveloped in these portions, because the pronounced moraine would ndicate that many were present immediately after the recession f the ice; but rather to the fact that many streams and their ributaries worked their heads back into this moraine, and

thoroughly drained at a time sufficiently prior to the present, that decomposition has had a chance to decompose almost all of the organic matter, that once collected in the ponds and marshes."

Drainage. -- The northern part of Randolph County lies within the Wabash drainage area. The central part of the county is within the White River drainage basin and the waters of the southern part of the county are carried to the Ohio River .

The Mississinewa River, a branch of the Wabash, flows across the northern part of the county at a distance of from one to two miles from the northern boundary. From the south it receives Elkhorn Creek, Bear Creek, and other short tributaries.

The East Fork of White River flows across the central portion of the county from east to west and receives in that order the following southern branches: Sugar Creek, Eight Mile Creek, Sparrow Creek, Cabin Creek, Little White Creek, and Stony Creek.

The southern part of the county is drained by tributaries of Whitewater River. These branches are from east to West, Salards Fork, Greens Fork, Martindale Creek, and the West branch of Whitewater River.

The drift of this county is composed largely of blue till, though in the deep wells sand and gravel are encountered. The drift ranges from a few feet to as much as 300 feet.

The alluvial deposits along the various streams are locally of importance as ground water sources, especially those of the first bottoms. The second bottoms are also sources of ground water, though drain out and locally springs are produced. A few muck beds ranging in thickness from 2 inches to 2 feet occur in undrained depressions, on both uplands and stream bottoms.

Outcrops of bedrock occur along the Mississinewa, in the vicinity of Ridgeville, and on White River in the western part of the county. It has been estimated that the drift has an average thickness of 150 feet. Wells drilled near Winchester showed an average thickness of 136 feet, and a range from 75 to 350 feet.

The bedrocks which underlie the drift in this county and which are quarried in a few places are of Niagaran age. Cumings and Shrock (140) has described the quarries of the county as follows:

(140) Cumings, E. R. and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, Publication No. 75, Dept. of Conservation, State of Indiana, 1928, p. 171.

"The Niagaran strata of Randolph County have furnished materials for both lime burning and road building. At the present time only two quarries are active, and they are producing crushed stone. Numerous abandoned quarries are found in the northern half of the county. One-half mile east of Ridgeville a large quarry, several acres in extent and from 35 to 70 feet deep, is furnishing thousands of tons of crushed stone and

ound limestone to a local market. The upper 20 feet in the quarry nsist of evenly-bedded, very fossiliferous, yellow to white layers dolomite, but the lower 50 feet are massive, with few stratification planes and greater hardness. This stone is of Huntington age. is found along the recently excavated channel of the Mississiwa River from Ridgeville eastward to the village of Deerfield. the latter place a small abandoned quarry is said to be present the NE of NE¼ of Sec. 17, T. 21 N., R. 14E., on the south bank the river. At Macksville (Maxville), Sec. 20, T. 20N., R. 13 , occur several outcrops of the Huntington dolomite. It has been arried and burned for lime along the south bank of the White ver. Several years ago a small quarry was opened in the north nk of the river, just north of the outcrops in the river channel, t was never operated. South of this exposure, near the cemetery, one was once quarried and crushed, but the quarry is now filled th water and the crusher has been taken away. The beds in ese quarries are similar to the lower beds of the Ridgeville arry. Two miles east of Fairview, along the line between sections and 11, T. 21 N., R. 12 E., a small quarry has been opened in the ntington dolomite. It is located on the south bank of the ssissinewa River and will undoubtedly fill with water when abanned. The stone is crushed and used locally for road repair."

Many wells have been drilled in Randolph County during the velopment of the oil and gas resources. The producing horizon s the so-called Trenton limestone of Ordovician age. Salt ter usually accompanied the oil production.

Generalized Geologic Section for Randolph County

aternary:
- Recent, -- alluvium. . . . . 0- 25'
- Pleistocene, -- glacial deposits . . . . . 0-350'

lurian:
- Huntington, -- dolomite. . . . . 70' exposed
- Liston Creek, -- limestone (not exposed)
- Mississinewa, -- shale (not exposed)

Sources of Water Supply

Surface waters may be obtained in Randolph County from streams d springs. Surface water supplies may be augmented by the imunding of water in streams and on the water-shed areas.

Ground water supplies are available from the drift, alluvial ats, and from the bedrock. The contact between the drift and drock is a good water horizon. The upper surface of the ntington dolomite which underlies the county, is a good aquifer. is porous and when wells are drilled a few feet in the dolomite od water usually is obtained.

Wells drilled into the deeper rock formations are not likely procure potable water supplies.

Leverett (141) has given considerable information about wells

(141) Leverett, Frank, Wells of Southern Indiana, Water-Supply and Irrigation Paper No. 26, U. S. Geological Survey, 1899. pp. 7-9.

in Randolph County as follows:

"Along the Mississinewa moraine, on the north border of the county, several wells show a depth of 90 to 100 feet before entering rock. The drift is mainly a blue till.

"At Ridgeville wells penetrate 30 to 40 feet of drift. A few are obtained without entering rock, but the best supply is to be found in the limestone. Many wells are obtained at a depth of only 40 feet.

"On the plain between the Mississinewa moraine and the Union City ridge wells are usually obtained at less than 40 feet, and are mainly through till.

"The drift in the vicinity of Union City ranges from 60 feet to fully 200 feet. Ordinary wells at Union City are obtained at a depth of about 35 feet in gravel beneath the blue till. The waterworks wells are estimated to yield about 1,500,000 gallons each per day. Two wells supply the city.

"At Winchester the dug wells are often obtained at a depth of but 10 or 20 feet, and water is usually struck at 7 to 10 feet. Such wells being liable to contamination, deeper ones have been sunk, which obtain water near the top of the limestone at about 100 feet.

"The deepest drift yet discovered in Randolph County was found in two wells about 1½ miles west and northwest from Winchester. In one well rock was struck at 331 feet; in the other at 334 feet. The upper portion of the drift at these wells is till, but the greater part is sand containing water.

"At Farmland, in the western part of the county, the drift in two gas wells is 58 and 60 feet, mainly till. Water wells are obtained at about 25 feet.

"At the village of Parker, also in the western part of the county, water wells usually are obtained at 20 to 60 feet in thin gravel beds between sheets of till. A boring at the grist mill, however, extends to the rock at 97 feet, and is mainly through till. A gas-well boring in Parker struck rock at 80 feet.

"At the village of Windsor, on White River, south from Parker, the drift is mainly sand and gravel, and a gas-well boring shows its depth to be 107 feet. . . . . .

"The wells on the moraine in southern Randolph County, near the State line, usually obtain water at 20 to 30 feet, occasionally at 50 to 60 feet, in beds of gravel, between sheets of till."

During the course of the present investigation inquiry concerning the source of supply of 22 wells was made. Thirteen produced water from sand and gravel, seven from limestone, and two

from both gravel and limestone. This would indicate that the glacial drift is still the chief source of water supply in Randolph County.

Typical Wells in Randolph County

Location	Depth	Quality	Quantity	Formation	Construction.
T20N-R12E					
Sec. 6	140'	Hard	Good	Limestone	Drilled
T21N-R13E					
Sec. 25	50'	"	"	"	"
Sec. 32	100'	"	"	"	"
T21N-R14E					
Sec. 30	136'	"	"	"	"
Sec. 35	22-80'	"	"	Gravel and lime	"
T20N-R14E					
Sec. 13	65'	"	"	Gravel	"
Sec. 24	20-100'	"	"	Gravel and lime	Driven & Drilled
T19N-R14E					
Sec. 2	60-90'	"	"	Gravel	Drilled
Sec. 13	50-20'	"	"	"	"
T19N-R13E					
Sec. 2	36'	"	"	"	"
Sec. 9	30'	"	"	"	Driven
Sec. 11	20'	"	"	"	"
T19N-R12E					
Sec. 13	20-40'	"	"	Sand	Dug and Drilled
Sec. 21	20'	"	"	Gravel	Driven
T18N-R13E					
Sec.11-12	30-40'	"	"	Sand and Gravel	Drilled and Dug
Sec. 29	80'	"	"	"	Drilled
T18N-R14E					
Sec. 7	40-108'	"	"	Sand and Gravel	"
Sec. 12	185-143'	"	"	Limestone	"
Sec. 13	100'	"	"	Gravel	"
Sec. 34	25'	"	"	"	Driven
Sec. 34	20-30'	"	"	"	"
T19N-R14E					
Sec. 33	190'	"	"	Limestone	Drilled

Water Supplies of Towns in Randolph County

Ridgeville. -- (population 909). The town of Ridgeville owns its water supply system. Two wells produce water from the underlying limestone. The water level is 9 feet below the surface. Bedrock is reported at 15 feet. The water is hard otherwise a good supply is obtained.

Farmland. -- (population 853). The town of Farmland owns its public water system. Two wells drilled into bedrock, penetrated at 32 and 38 feet furnish the water. The water level is found at varying depths in the community, from 10 to 40 feet below the surface.

Parker City. -- (population 794). The town of Parker City owns its public water supply. One well drilled to 152 feet produces the water. The dolomite was penetrated at 90 feet. The water level in many private wells in the area is about 17 feet below the surface.

Lynn. -- (population 936). The town of Lynn has its own water supply. Two wells furnish the supply, total depth unknown, but bedrock is reported at 134 feet. The depth to water level is 38 feet.

Union City. -- (population 3,084). The city of Union City has a municipal water department. Five wells furnish water from the underlying limestone, and the water level is from 11 to 15 feet below the surface.

Winchester. -- (population 4,487). Winchester is furnished water by the Citizens Heat, Light & Power Co., a private corporation. Eight wells produce from the limestone. The rock wells are reported to have a water level of 20 feet below the surface and the gravel wells stand about 10 feet below.

The town of Bronson, (population 252); Modoc, (population 236); and Saratoga, (population 303), do not maintain public water systems.

RIPLEY COUNTY

GENERAL FEATURES

Area 448 square miles Population 18,078(Census of 1930)

Ripley County is located in southeastern Indiana. It is the second county west of the point where the Ohio River first touches the State of Indiana. Versailles is the county seat.

The maximum altitude of the county is 1,030 feet above sea level, the minimum is 550 feet, thus giving a maximum relief of 480 feet. The maximum local relief is 300 feet. The eastern half of the county is a portion of the Dearborn Upland, the western half is included in the Muscatatuck Regional slope. The underlying bedrock is largely responsible for the topographic development. East of Laughery Creek the rocks are soft and easily eroded. The streams of this section flow in steep gorges and the drainage is to the Ohio which is not far distant. The eastern half of the county is much dissected. West of Laughery Creek the strata are more resistant and the streams have not cut down so rapidly, hence the surface is smoother, with the exception of the southwestern quarter where large streams have cut through leaving a maturely dissected surface.

Drainage. -- Ripley County lies partly within the Ohio River drainage basin and partly in the White River drainage area. The surface waters in the eastern part of the county are borne to the Ohio and those in the western part are carried to the White and ultimately reach the Wabash and through it to the Ohio.

The northeastern part of the county is drained by Pipe Creek, a branch of the Whitewater River, and its branches. Laughery Creek flows from north to south through the central part of the county and receives a number of short branches from both east and west. The Vernon Fork of the Muscatatuck River crosses the northwestern part of the county and with its tributaries Pipe, Sugar, Brush, and Otter Creeks drains the western and northwestern parts of the county; Big Graham Creek and Little Graham Creek are tributaries of the Graham Fork of the Muscatatuck which drain the southwestern part of the county.

GEOLOGY

The bottom lands of Ripley are comparatively small in extent, being found only on the inner sides of the bends of the streams, especially the Laughery Creek. The western valley side is precipitous with deposits of talus on the bluff side. The Niagaran strata form an escarpment west of Laughery Creek. Laughery Creek forms the dividing line between the soft impure limestones and shales of Ordovician (Cincinnatian) age on the east, and the Niagaran formation of the Silurian on the west.

The Illinoian drift covers the county, varying in thickness from 30 feet on the north to only three to five feet on the south. In the eastern part of the county stream action has been more vigorous and has transported much of the glacial debris away. The resistant Niagaran strata west of Laughery Creek has not permitted the streams to cut down and little of the debris has been removed. This has resulted in the formation of swamps. Ground water is more easily obtained in the western part of the county.

One small outlier of Devonian strata has been mapped in the southwestern part of the county, north of Little Graham Creek. It is of little importance with respect to ground water.

Generalized Geologic Section for Ripley County

Quaternary:	
Recent, --	0- 15'
Pleistocene, --(Illinoian drift)	0- 50'
Devonian: (small outlier)	Few feet
Silurian:	200'±
Ordovician:	
Cincinnatian, --	600'±

GROUND WATER

The ground waters of Ripley County are of sufficient head in certain localities to furnish private supplies. Other areas must depend on reservoirs, cisterns or stream water, especially for public supplies. The glacial drift is of importance, where it is sufficiently thick and in the northwestern part of the county furnishes water. In many areas the drift exists only as remnants and the upper limestone formations must furnish the supply. The Silurian limestones carry ground water and unless drained by streams are of importance as acquifers. The eastern part of the county underlain by Ordovician clays and limestones is not so fortunate with respect to ground water. Cisterns are in frequent use.

Sources of Water Supply in Ripley County Towns

Osgood. -- (population 1,173) The town of Osgood owns its water system. The supply is obtained from Laughery Creek.

Milan. -- (population 877) The town of Milan owns its public water supply, obtained from tubular wells,

Batesville. -- (population 2,838) The city of Batesville owns its public water supply, obtained from impounding reservoir.

Other towns in Ripley County are Versailles (population 523); Synman (population 355);which maintain no public water supply system.

RUSH COUNTY

GENERAL FEATURES

Area 409 square miles Population 19,412 (Census of 1930)

Rush County is located in southeastern central Indiana. It is the third county west of the Indiana-Ohio State line and the fourth county north of the Indiana-Kentucky State line. Rushville is the county seat.

The highest elevation in the county is 1116 feet above sea level, the lowest is 825, thus giving a total maximum relief of 291 feet. The maximum local relief is 75 feet. Rush County was covered by both Illinoian and Wisconsin glaciations. As a whole the surface is a gently undulating plain, broken by the valley of the Big Blue River in the northwestern corner, the rather shallow valley of Big Flat Rock traversing the county from the northeastern corner to the southwestern and some glacial kames and ridges near Mays, Hamilton Station, Homer, and the southeastern corner.

Drainage. --Rush County lies mainly within the drainage basin of the East Fork of White River. Tributaries of this stream control the drainage of the entire county except a small area in the southeastern part. Big Blue River crosses the northwestern part of the county. It receives from the north, Six Mile Creek and from the east, Three Mile Creek. Little Blue River crosses the northwest-central part of the county. It receives the water from two northern branches, Meadown Creek and Gibson Branch.

Flat Rock Creek drains the larger part of the southern and northeastern portions of the county. It receives from the north Shankitank Creek, and from the northeast Middle Fork and Shawnee Creek. From the east it receives Ben Davis Creek, Salt Creek, and Bull Creek tributaries of the Whitewater River which drains a part of southeastern Rush County. Flat Rock Creek has two northern branches within the county, Coons Creek and Deer Creek.

GEOLOGY

The unconsolidated deposits of Rush County consist of glacial drift, valley flat alluvial materials and terrace deposits, with some outwash gravel deposits away from the morainic deposits.

The terrace and flood plain areas occur along Big Flat Rock, Little Flat Rock and Big Blue Rivers. Moraines of the Wisconsin glacial epoch occur in the very northwestern corner of the county, one belt extends from the southwestern to the northeastern corner, and the outermost Wisconsin terminal moraine is barely represented in the southeastern corner, See PlateIII accompanying this report for distribution of the moraines.

The bedrock strata of this county are of the Silurian and Devonian systems. The northeastern one-half of the county is underlain by Silurian rocks, the southwestern one-half by Devonian. These boundary divisions are only approximate. Inliers of Silurian outcrop along Big Flat Rock and Little Flat Rock Creeks in the southwestern part of the county.

A study of the logs of wells drilled in this county shows that the bedrock surface is very uneven and that frequently wells close together penetrate the bedrock at varying depths. Pre-glacial erosion of the surface is perhaps the explanation.

Generalized Geologic Section for Rush County

Quaternary:	
Recent, -- chiefly alluvial deposits	0- 30'
Pleistocene, -- glacial deposits	0-150'
Devonian:	0-160'
Silurian:	200' ±
Ordovician: (Not exposed)	

GROUND WATER

The glacial drift is the chief source of ground waters in Rush County. Many wells penetrate the bedrock, but most of the private supplies are obtained from drift, Leverett (142) has

(142) Leverett, Frank, Wells of Southern Indiana, U.S, Geological Survey, Water Supply Paper No, 26, 1899. p. 36

given the following data on wells in Rush County:

"In the vicinity of Raleigh, on the gravel plain in the north part of the county, several flowing wells have been obtained at depths ranging from 65 to 106 feet. They have a head three to six feet above the surface. The water is obtained from gravel below a sheet of till, but the wells penetrate a large amount of surface gravel before entering the till.

"Along the moraine in the northern part of the county and on the plain west of it wells usually enter sand below till at 12 to 25 feet. In some cases the wells have been sunk some distance into sand before obtaining water. At Hamilton Station one well penetrates 92 feet of sand.

"Near Carthage, in the northwestern part of the county, on the gravel plain along Blue River, rock is sometimes struck at a depth of 50 feet, and the drift is mainly gravel. At Arlington, in the western part, wells are usually obtained in sand below till at a depth of 20 to 30 feet.

"At Homer the drift is mainly sand after penetrating a few feet of surface till, and water is obtained at 20 feet or less. The gas well enters rock at 53 feet.

"A gas well seven miles north of Rushville penetrates 147

feet of drift - - mainly sand, 92 feet; blue till, 55 feet.

"At Rushville, a gas well near the school building penetrated 60 feet of drift, mainly till. Water wells at Rushville are obtained at depths ranging from 14 to 75 feet. Several flowing wells have been obtained from the drift in and near the city along the valley of Flat Rock Creek. They are strongly chalybeate and also sulphurous.

"At Glenwood, near the eastern border of the county, a gas well penetrates 120 feet of drift, of which the upper 60 or 70 feet is till and the remainder sand and gravel. Wells are obtained in the vicinity of that village at depths of 20 feet or less, though an occasional tubular well is sunk to the underlying heavy bed of sand.

"At New Salem, in the southeastern part of the county, wells are obatined in sand below till at 40 or 50 feet.

"Along the morainic ridge in the extreme southeastern part wells in some cases are sunk to a depth of 60 feet, mainly through till.

"Along the southern border rock ledges appear in the bluffs of streams at 20 to 40 feet below the level of the bordering uplands, but wells usually obtain water without entering the rock."

Water Supplies of Towns in Rush County.

Carthage. -- (population 931). The town of Carthage has no public water supply. Private wells are drilled into the gravels which furnish the water, for citizens of the town.

Rushville.-- (population 5,709). The city of Rushville owns its water supply system. Six tubular wells drilled into glacial drift furnish the water. The water level is about 30 feet below the surface.

Glenwood. -- (population 374). The town of Glenwood has no public water supply.

S C O T T C O U N T Y

GENERAL FEATURES

Area 190 square miles Population 6,664 (Census of 1930)

Scott County is situated in the southeastern part of the State. It is bounded on the north by Jackson and Jennings counties, being separated from them by the Muscatatuck River; on the east by Jefferson County; on the south by Clark and Washington counties, and on the west by Washington and Jackson counties. Scottsburg is the county seat.

The maximum elevation in Scott County is 1,015 feet above sea level, the minimum is 520 feet. The maximum relief is 495 feet, and the maximum local relief is 400 feet. Two physiographic units are represented in this county. Most of the county is a part of the Scottsburg Lowland, which is underlain by the soft non-resistant Devonian shale. The southwestern part of the county is characterized by the Knobstone hills, which have an elevation of from 200 to 400 feet above the drainage level of the county north and east of them. The western one-third of the county is underlain by Mississippian (Borden and Rockford) strata.

Drainage. -- The surface waters of Scott County are largely controlled by the East Fork of White River and its tributaries. The Graham Fork of the Muscatatuck River forms the boundary for the morthern part of the county and for a portion of the western part. Stuckers Fork of the Muscatatuck drains the central portion of the county and receives Kimberlin branch from the southeast. Ox Creek and its tributary, Little Ox Creek, drain the southwestern part of the county. Roger Run and a branch of Fourteen Mile Creek drain a portion of the southeastern part of the county and carry waters to the Ohio River through Clark County. The drainage of the county is well developed. Each of the principal streams has a large number of branches although many of them are short.

GEOLOGY

The unconsolidated deposits of Scott County consist of glacial drift, alluvium, and residual soils. The drift deposits as a rule are thin, averaging les than 20 feet. In the north part of the county, however, on the borders of the Muscatatuck, there is at least 50 feet of drift.

The bedrock strata of the county are of Devonian and Mississippian age. Devonian rocks occur in the eastern two-thirds of the county and Mississippian strata either out-crop or underlie the drift in the western one-third of the county.

Generalized Geologic Section for Scott County

Quaternary:

Recent, -- alluvium	0- 20'
Pleistocene, -- glacial drift	0- 50'

Mississippian:
Borden, -- (Calculated by Stockdale) . . . . . 645' (at Austin)
Rockford, ... 2- 5'
Devonian:
New Albany, -- shale. . . . . 100'
Middle Devonian, -- limestone . . . . . 50'
Silurian: (Not exposed. Reported from well records only.)

GROUND WATER

Where the drift materials are sufficiently thick and are not drained by streams at lower levels, ground water may be secured in adequate quantities. In many parts of the county the drift is thin and is not an aquifer. Deeper wells must be drilled. Where the Devonian limestones are only a few feet from the surface as in the eastern part of the county, ground water is fairly easy to obtain. Most of the county is underlain by Devonian shale and Mississippian (Borden) rocks which are not aquifers of the first order. Some water may be obtained from these formations but they are relatively impervious. Frequently the water from the shale and siltstone is unfit for use. Leverett (143) has given the following information about individual wells in Scott County:

(143) Leverett, Frank. Wells of Southern Indiana, U.S. Geol. Survey, Water-Supply and Irriguation Paper No. 26, 1899, pp. 55-6

"At Scottsburg, the county seat, wells are usually obtained at 25 to 35 feet or less. The drift is about 50 feet. A gas-well boring near the railway station penetrates 47 feet of drift as follows:

1. A Yellowish white clay, nearly pebbleless . .	15'
2. Sand , ...	5'
3. Blue till.	27'
Total	47'

"A boring at the fair ground, a mile southeast from Scottsburg, entered rock at 40 feet. It encountered much wood in a blue till in its lower part.

"At Little York, neat the west line of the county, wells usually enter shale at 15 or 20 feet, and obtain water at depths of 25 to 45 feet. Within a mile east from Little York a thicker drift sets in and wells are obtained without entering the rock at depths of 25 feet or less.

"At Vionna, a well at the canning factory enters rock at 12 feet and obtains water at about 30 feet.

"At Summit, or Underwood Station, near the south line of the county, wells usually enter shale at about 8 feet, and obtain water at 20 to 30 feet. A well at Mr. Hosea's, one-half mile west of this village, 40 feet in depth, enters shale at 25 feet, but its water supply is from gravel at from 12 to 25 feet.

"At Lexington, in the east part of the county, wells enter limestone within a few feet of the surface and obtain water at depths of 20 to 30 feet or less."

Water Supplies of Towns in Scott County.

Scottsburg. - (population 1,702). The town of Scottsburg owns its water system. The supply is obtained from dug wells.

SHELBY COUNTY

GENERAL FEATURES

Area 407 square miles . . . Population 26,552 (Census of 1930)

Shelby County is located southeast of the central part of the State. It is the fourth county west of the Indiana-Ohio State line, and the fifth county north of the Indiana-Kentucky State line. Shelbyville is the county seat.

The maximum elevation of the county is 920 feet above sea level, the minimum elevation is 550 feet, thus giving a total maximum relief of 270 feet. The maximum local relief is 75 feet. In general the surface is level to gently rolling, with the slope to the west and south. The Wisconsin glaciation modified the surface. Morainal remnants still exist in the northwestern part of the county, also in the southeastern and southern portions. The areas of morainal ridges give a more diversified expression. Gravel trains lead away from the ridges. They are outwash from the moraines.

Drainage. -- Shelby County lies within the Big Blue River basin. The Big Blue River crosses the county from near the northeastern corner to within a few miles of the southwestern corner. Sugar Creek, Little Sugar Creek, and Grass Creek are tributaries of Big Blue River, which drain an area in the northwestern portion of the county. Brandywine Creek is the principal branch of Blue River draining the northern part of the county. Flat Rock Creek, another tributary of the Blue, controls the drainage of the southern part of the county. Its principal branches from the north are Slash Creek, Lewis Creek, and Coons Creek. The drainage in the extreme southeastern part of the county flows into Haw Creek, Clifty Creek, and their tributaries.

GEOLOGY

The unconsolidated deposits of Shelby County consist of glacial drift, stream alluvium, and residual soils. The drift is assorted with considerable sand and gravel near the surface. Various writers have called attention to the stratified drift of this county which suggests that water was present in large quantities during the depositional stages. Silt or loess occurs in abundance in the upper layers of the soil. The first bottoms of the streams are locally of importance as sources of ground water.

The bedrock of the county are of Silurian and Devonian age. The Silurian occurs along Flat Rock Creek and Deer Creek in the eastern part of the county, just west of St. Paul. They outcrop only over a small area, but dip westward under the Devonian strata. The Devonian rocks either outcrop or underlie the surficial materials over the area of most of the county. Well records and outcrops have aided in mapping the general distribution of the strata.

Generalized Geologic Section for Shelby County

Quaternary:

Recent, -- alluvium and residual materials . . . . 0- 20'
Quaternary, -- glacial drift, outwash gravels . . 0-150'

Devonian:
New Albany, -- shale . . . . . 100'
Middle Devonian, -- limestones . . . . . 40-- 50'
Silurian:
(Not all exposed) . . . . . .

GROUND WATER

The drift and outwash plains of the county are the chief source of ground water. The drift of the uplands in the eastern part of the county is composed largely of till and has a depth of 50 ft. or more. The wells are usually obtained without entering rock. The water occurs mainly in sand or gravel associated with the till. In the western part there appears to have been a preglacial basin with a rock surface much lower than that of the eastern portion of the county. This accounts for the great thickness of drift, as much as 150 feet in this section. Leverett has given information on individual wells (144) as follows:

(144) Leverett, Frank, Wells of Southern Indiana, Water-Supply Paper No. 26, U. S. Geological Survey, 1899. pp. 37-40.

"Gas wells in the northwestern part of the county penetrate 150 to 200 feet of drift, of which the greater part is till. The water wells of that region are usually obtained at a depth of 15 to 50 feet, but occasionally reach a depth of 100 feet.

"Wells on the gravel plain along East White River, above Shelbyville, have in several instances reached the bottom of the gravel and entered till at a depth of 25 to 30 feet.

"The gravel plain along Brandywine Creek, east and northeast from Fairland, carries about 30 feet of gravel, beneath which is a sheet of till.

"In Fairland, the wells in the north part of the village penetrate 15 to 25 feet of till, at which depths they enter a water-bearing gravel. The southeast part of the village extends into the gravel plain, and wells there are obtained at similar depths without penetrating till.

"At Waldron, in the southeast part of the county, the drift is in places 80 feet in thickness, as shown by gas borings. A water well in the village is reported to have entered rock at 53 feet. It penetrates:

Yellow till	10'
Sand and gravel	14'
Gray till	28'
Sand	1'
Rock, thought to be sandstone	3'
Total	56'

"At St. Paul, the drift varies from 15 feet or less to nearly 100 feet in depth. The following depths are reported in gas-well borings; 17 feet, 87 feet, 16 feet, 23 feet, and surface outcrops.

"Mention is made in the eleventh report of the State geologist of two wells in this county having water of exceptionally high temperature. One in the east part of Shelbyville, 24 feet in depth, is reported to maintain a constant temperature, winter and summer, of 76 degrees Fahrenheit.

The other well, located four miles west of Shelbyville, is said to have increased in temperature after it was made, the water becoming too warm for drinking purposes, its temperature having reached 65 degrees Fahrenheit. A pipe was driven in the bottom of the well to a depth of 16 feet, or 39 feet from the surface. The water was then found to have a temperature of 80 degrees, and during the winter increased to 86 degrees Fahrenheit. As these wells were excavated for potable water only, they have been filled.

"Almost two-thirds of Shelby County is underlain by Devonian limestones which ordinarily are aquifers. The southwestern one-third is underlain by Devonian shale, which is relatively impervious and not considered a source of water.

"Owing to the abundance of water in the drift and outwash plains, the limestone aquifers are little used. Also the expense of penetrating thick sections of drift makes these horizons prohibitive for individual wells."

Water Supplies of Towns in Shelby County.

Shelbyville, -- (population 10,618) The city of Shelbyville is supplied with water from fifteen wells. The supply is privately owned. Limestone is reported to be the water-bearing stratum, which was struck at 75 feet. Water stands at about 15 feet in the wells.

Morristown. -- (population 688) The town of Morristown owns its water supply, obtained from one tubular well, producing from gravel. It is 64 feet to the water level.

St. Paul. -- (population 678; in Shelby County 195, in Decatur County 483)
The town of St. Paul has no public water system.

SPENCER COUNTY

GENERAL FEATURES

Area 403 square miles Population 16, 713 (Census of 1930)

Spencer County is located in extreme southern Indiana. Its southern boundary is the Ohio River. It is the fourth county east of the Indiana-Illinois State line. Rockport is the county seat.

The maximum altitude of the county is 660 feet above sea level the minimum is 338 feet, thus giving a total maximum relief of 322 feet. The maximum local relief is 220 feet. All of this county is included in the Wabash Lowland.

Drainage. -- The drainage of Spencer County belongs to the Ohio River system with the exception of a small area in the northern part of the county which passes eventually to the Ohio through the Patoka River and the Wabash.

Little Pigeon River forms a portion of the western boundary of the county and drains that portion through numerous short branches Its principal northern branch is Wallace Creek. Anderson River forms the boundary for the eastern part of Spencer County. The Ohio River forms the boundary for the southern part of the county. Three small tributaries flow through the southern part of the county into the Ohi River. These are Crooked Creek, East Sandy and West Sandy creeks.

GEOLOGY

Spencer County is within the driftless area of the State. The unconsolidated materials consist of stream deposits along the Ohio River and the lower courses of other streams. The wide bottoms along the Ohio below Rockport are underlain chiefly by sand which contains an abundance of ground water. These alluvial deposits are from 20 to 40 feet in depth. The Little Pigeon Creek valley is approximately four miles in width. The streams in this area usually overflow after heavy rains or long wet periods, and the soils found in the valleys are of a silty or clayey character.

The bedrock formations of the county are Pennsylvanian in age. The Pottsville series outcrop in the eastern half of the county and the Alleghany series in the western half.

Generalized Geologic Section for Spencer County

Quaternary:	
Recent, --	0- 50'
Pleistocene, -- (Ohio River terraces)	0- 50'
Tertiary: (high Gravels)	0- 25'
Pennsylvanian:	600'±
Alleghany,--	400'±
Pottsville, --	200'±
Mississippian: (No outcrops. From well logs only)	
Devonian: (No outcrops. From well logs only.)	

GROUND WATER

Springs, streams, and impounding reservoirs supply many residents of Spencer County with water. Shallow wells are in

frequent use. Along the flood plains of the Ohio and other streams shallow wells are easy to obtain. In the upland areas sufficient supplies may be obtained from wells, though, in some instances the Pennsylvanian shales preclude the possibility of obtaining water. The coal horizons in most instances bear water, though in some cases the water is mineralized and unfit for use. Frequently individual home supplies of water are obtained from stream gravel and sand deposited in valley flats. The Mansfield sandstone is the basal Pottsville formation of the county. It has been quarried at St. Meinard. The Mansfield in some areas bears fresh water. In Spencer County the formation apparently is cemented with silica and does not carry much water. Logan (145) has published the logs of 55 well drilled in Spencer County for oil and gas prospects.

(145)Logan, W. N. The Subsurface Strata of Indiana, Publication No. 108, Dept. of Conservation, State of Indiana, 1931, pp. 670-96.

A study of these logs shows that ground water occurs at many Stratigraphi horizons in the Pennsylvanian and Chester formations. In most cases the deeper wells bear salt waters and individuals can ill afford to bear the expense of drilling and lifting water at any considerable depth. Aquifers to be of value must be near the surface.

Water Supplies of Towns in Spencer County

Rockport. -- (population 2,396) The city of Rockport receive an unlimited water supply from four wells drilled into gravel. The city is supplied water by a private corporation. Water is reported at a depth of 40 feet.

Dale. -- (population 770); Chrisney (population 414); Grandview (population 588); and Gentryville (population 271) are other incorporated towns in Spencer County. They do not maintain public water systems.

STARKE COUNTY

GENERAL FEATURES

Area 305 square miles Population 10,620 (Census of 1930)

Starke County is located in northwestern Indiana, the second county south of Michigan and Lake Michigan, and the third county east of the Illinois-Indiana State line.

The highest elevation in Starke County is 760 feet above sea level which is the average altitude for the State of Indiana. The lowest elevation is 660 feet above sea level, thus giving a maximum relief of 100 feet. The maximum local relief is 60 feet.

Physiographically Starke County is a portion of the Kankakee Lacustrine Section of the Northern Moraine and Lake Region of Northern Indiana. The surface of the county is predominantly flat and smooth, and characteristic of an old lake plain. The only pronounced irregularities are the sand ridges of dune-like hills, which are of common occurrence and a weak morainic belt in the southeastern part. In the early development of Starke County, drainage played an important role. The Kankakee River, Yellow River, and other smaller streams formerly overflowed wide areas and much marsh land resulted, however, in recent years dredging and ditching have improved the general drainage situation.

The drainage of Starke County is included in the Kankakee River drainage basin with the exception of a very small area in the southeastern part of the county. Tippecanoe River reaches the county boundary in the southeast portion of the county where the drainage carried by Griffith ditch is brought to it.

The southwestern part of the county is drained by Payne Ditch, by Pine Creek and Bogus Run. These are all eastern branches of the Kankakee River. The central and eastern parts of the county are drained by Yellow River and its branch, Latimore Ditch and Swith's Ditch and its branch Cottonwood Ditch. These carry their waters to the Kankakee. State Ditch drains the north part of the county.

GEOLOGY

Starke County lies within the glaciated region of Indiana. This area during the latter part of the glacial period and for some time following the glaciation, especially the area adjacent to the Kankakee valley, seems to have been occupied by an extensive lake or marsh. This permitted the accumulation of sand in the old lake areas. Subsequently this sand has locally been blown into dunes. The underlying deposits consist of grayish-blue calcareous boulder clay with many changes to gravel and sand. The sandy mantle at the surface will average perhaps 25 to 40 feet in thickness. Bedrock is found at depths varying from 140 to 200 feet.

The morainic area in the southeastern part of Starke County is rolling and consists of gravels, clays and till.

General Geological Section for Starke County

Quaternary:
Recent, -- sands and clays . . . . . 0- 40'
Pleistocene, -- glacial sands, gravels, clays. . . 40-200'
Devonian: (No exposures) sandstone, limestone, shale:
Silurian: (No exposures) limestone, shale:
Ordovidian: (No exposures) shales and limestone
(Cincinnatian), limestone (Trenton) Mohawkian

Sources of Water Supply in Starke County

Surface water supplies in Starke County are obtained from streams, springs, and lakes. There are eight lakes in the county and it has been estimated that there are 2,000 acres of water surface in the county. There are 200,960 acres in the entire county.

The largest lake is Bass Lake which is situated partly in the eastern part of California Twp. and partly in the western part of North Bend Twp. English Lake is on the Kankakee River in Jackson Twp. Round Lake is a small lake in the northwestern part of California Twp. Eagle Lake is in the eastern part of Washington Twp. about one mile from the eastern border of the county. Koontz Lake is in the northwestern part of Oregon Twp. There are three small lakes in the southeastern portion of North Bend Township.

GROUND WATER

Ground waters may be obtained from a number of geological horizons in Starke County. The lacustrine deposits of the county bear water at shallow depths. Too much water at and near the surface was a source of much trouble in the early days of Starke County. Artificial ditches have lowered the water- table in most places in the county so that surface soils might be utilized.

The lacustrine deposits and the till underlying these beds and the till beds in non-lacustrine areas are all sources of ground water. Most of the wells in Starke County receive supplies of water from these sources.

Logs of wells drilled into bedrock in various places throughout the county show a thickness of glacial drift ranging from 150 to 250 feet.

Water occurs in the rocks underlying the drift in the county. In most parts of Starke County the New Albany shale of the Devonian underlies the glacial drift and this shale is almost impervious to water. At least it is not considered a good water-bearing formation, therefore, wells must penetrate the limestones and sandstones underlying the black shale before an abundance of good water is obtained. Below the Devonian water-bearing formations are found the Silurian limestones which bear good water in various parts of Indiana. It is quite possible that both the Devonian and Silurian rocks of Starke County will carry mineral waters, and it is known definitely that the deeper limestones of the Ordovidian bear salt water in the county.

Water Supplies of Towns in Starke County

Knox. -- (population 1,815) The town of Knox owns its public water supply, which is obtained from tubular wells.

Hamlet. -- (population 418) Hamlet has two wells drilled to

a depth of approximately 90 feet and producing water from the gravels of the drift. Water stands from 5 to 10 feet below the curb in the wells. The town owns the supply.

North Judson. -- (population 1,348) North Judson obtains a supply of water from three wells drilled in 1915. Water stands at 8 feet below the curb in the wells and the source is the gravels of the drift or lacustrine deposits. If the wells are not deep the wate comes from the drift. A deep well drilled here showed the bedrock at 198 feet. Till occurs beneath the sand of the old lake depositio Artesian wells occur on lower ground near North Judson. The town of North Judson owns its water supply.

Typical Wells of Starke County

Location	Depth	Quality	Quantity	Formation	Construction
T34N-R1"					
Sec. 12 SW¼	65'	Medium	Good	Gravel	Driven
Sec. 27 NE¼	80'	Hard	"	"	"
T34N-R2W					
Sec. 24 SE¼	102'	"	"	"	"
Sec. 26 SE¼	30-40'	"	"	"	"
T33N-R2W					
Sec. 3 SE¼	25'	"	"	"	"
Sec. 22	100'	"	"	"	Drilled
Sec. 34	40'	"	"	"	"
T33N-R1"					
Sec. 19	75'	"	"	"	"
Sec. 10	45'	"	"	"	"
Sec. 14	75-80'	"	"	"	"
Sec. 19 SE¼	35'	"	"	"	Driven
T32N-R3W					
Sec. 17	225'	"	"	Limestone	Drilled
T32N-R4W					
Sec. 16 SW¼	30'	"	"	Gravel	Driven
Sec. 23 NE¼	35'	"	"	Sand& Gravel	Driven

S T E U B E N C O U N T Y

GENERAL FEATURES

Area 305 aquare miles Population 13,386 (Census of 1930)

Steuben County is situated in the extreme northeastern corner of Indiana, having Michigan on its northern and Ohio on its eastern boundary. The maximum altitude of the county is 1,200 feet and the minimum altitude is 920 feet, thus giving a maximum relief of 280 feet, however, the maximum local relief is 230 feet.

The southwestern part of Steuben County is drained by Turkey Creek and its branch, Mud Creek. The former is a branch of the St. Joseph River. The southeastern part of the county is drained by two branches of Fish Creek which is a tributary of the St. Joseph River which unites with the St. Mary to form the Maumee. Pigeon River rises in the northeastern part of the county, flows in a southwesterly direction to within three miles of the south line and then bears north-westerly to leave the county about six miles from the north line. The northwestern part of the county is drained by Crooked Creek and its branches.

Steuben County is entirely covered with glacial moraines and their associated lakes and marshes. These marshes are remnants of former lakes. The intermorainic areas are made up of outwash and gravel plains. This county is the type for Malott's Steuben Morainal Lake Section, described in the Handbook of Indiana Geology, 1922, p. 116.

GEOLOGY

The Wisconsin glacial drift covers the surface of Steuben County. The entire thickness of glacial drift approximates 350 feet, and is perhaps much thicker in given areas.

The bedrock underlying Steuben County consists of strata of Mississippian age. This surface of bedrock was probably eroded beford glacial times, thus giving a variation in thickness for the drift throughout the county. The drift has not been drilled through in many places so we do not know much about the bedrock.

A General Geological Section for the County is as follows:

Recent sands
Recent sands,clays and gravels, -- . . . . . .0- 40'
Pleistocene, sands, clays, and gravels, -- . . . . 330'
Mississippian: shales and sandstones . . . . . (no exposures)

(Determined from well logs)

Sources of Water Supply in Steuben County

Surface water supplies may be obtained in Steuben County indicating that the ground water table must be near the surface. The lakes are fed from underground sources and by streams. The water in many cases percolates down through the gravels, sand and till and often reaches the lake basin, thus acting as a feeding-ground. Only a few wells have been drilled through the glacial drift of Steuben County. One well drilled near Ashley penetrated

bedrock at 329 feet, which was probably in strata of Mississippian age, however, at 475 feet salt water occurred. It is not uncommon to find brine in strata of Mississippian age. Salt water occurs in the Devonian strata, also in the Ordovician. It seems that the deeper formations in this area are not to be depended upon to furnish a reliable supply of fresh water. Water supplies are so abundant in the glacial drift and so widely distributed that deeper sources are not needed.

Water Supplies of Towns in Steuben County

Angola, -- (population 2,665) Angola obtains a municipal supply of water from six wells drilled into glacial gravels. Bedrock was not penetrated. It is reported 78 feet to the water level in the wells.

The following towns do not have public water supply systems:
Hudson.--(population 431)
Ashley, --(population 623)
Fremont,--(Population 802)
Orland,--(population 310)
Hamilton,--(population 357)

Typical Wells of Steuben County

Location	Depth	Quality	Quantity	Formation	Construction
T36N-R14E					
Sec. 3	30-94	Hard	Good	Gravel	Drilled
Sec. 27	50-60	"	"	"	"
Sec. 18 SW¼	40	Medium	"	Sand	Driven
T37N-R14E					
Sec. 17 NE¼	50	Hard	"	"	"
Sec. 31 NE¼	60	"	"	Gravel	"
T37N-R13E					
Sec. 29 SW¼	40	"	"	"	"
T37N-R12E					
Sec. 28 SE¼	107	Medium	"	"	Drilled
T36N-R12E					
Sec. 4 SE¼	20-160	Hard	"	"	"
Sec. 9-10	24	"	"	"	Dug
Sec. 13 SE¼	65-160	"	"	"	Drilled
T37N-R14E					
Sec. 17 SE¼	50	"	"	Sand	Driven
T36N-R13E					
Sec. 15	30	Medium	"	Gravel	Driven
T36N-R15E					
Sec. 18 SW¼	120	Hard	"	"	"
Sec. 19 SW¼	40	"	"	"	"

Typical Wells of Steuben County (Continued)

Location	Depth	Quality	Quantity	Formation	Construction
T37N-R15E					
Sec. 5 SE¼	30-150'	Hard	Good	Gravel	Drilled
Sec. 17 NW¼	75	"	"	"	"
Sec. 32	65	"	"	"	"
T38N-R15E					
Sec. 29 SE¼	30	"	"	"	Driven
T38N-R14E					
Sec. 28	75	"	"	"	Drilled
T38N-R13E					
Sec. 22 NW¼	17-117	"	"	"	"
Sec. 23 SW¼	44	"	"	"	Driven
T38N-R12E					
Sec. 20	30	Medium	"	"	"
Sec. 22 NE¼	35	Hard	"	"	"

S T. J O S E P H C O U N T Y

GENERAL FEATURES

Area 460 square miles Population 160,033(Census of 1930)

St. Joseph County is located on the Indiana-Michigan line, midway of the State east and west. The average population per square mile is 348, according to the 1930 census report. It is interesting to note that in 1900 the average population per square mile was 128. South Bend, the third largest city in Indiana, is the county seat.

The maximum altitude of St. Joseph County is 875 feet, the lowest elevation is 654 feet and the average for the state of Indian

St. Joseph County is located in parts of three drainage basins, the St. Joseph, the Kankakee, and the Tippecanoe. The St. Joseph River enters the county from the east, flows west to South Bend and turns sharply northward into Michigan. The Kankakee River rises near the north-central part of the county and flows in a south-westerly direction to form a portion of the western boundary of the county. Several short branches of this collect the surface waters from the northwestern part of the county. The Kankakee River heads near South Bend and is separated from the St. Joseph by a low gravel flat. A large part of the Kankakee basin was once a lake bed and was quite marshy, however, much of the land has been reclaimed in recent years. The southeastern part of the county is drained by tributaries of Yellow River, which is a part of the Tippecanoe River system.

St. Joseph County has a maximum relief of 221 feet, though the maximum local relief is 100 feet. The lowland areas along the major streams are quite prominent and occupy a considerable portion of the county. The upland areas are morainal and till areas and occur chiefly in the south-central and southeastern portions of the county, with scattered morainal remnants in the northern part of the county. The entire county has been included by Malott in the Northern Moraine and Lake Region physiographic unit, with the county's southeastern quarter being a portion of the Steuben Morainal Lake Section and the remainder of the county included in the Kankakee Lacustrine section. The part of St. Joseph County within the Steuben Morainal Lake Section consists of uneven-surfaced drift 5 to 15 miles in width and is known as the Maxinkuckee moraine. Lakes and sloughs are prominent. The Kankakee Lacustrine Section consists of a system of sandy lacustrine plains, outwash plains, valley trains and local enclosed till plains.

During the Wisconsin glacial epoch the streams in this area were ponded permitting accumulations of lacustrine deposits, and glacial-fluviatile deposits along the stream courses.

GEOLOGY

The entire surface of St. Joseph County is directly or indirectly the result of glaciation. About one-half the county is a gravel plai formed by outwash from a retreating ice sheet. The Kankakee bottoms are typical of this condition, also the St. Joseph River has similar conditions. The Maxinkuckee moraine extending southward from South

Bend, the till plain in the southeastern part of the county and the till underlying the old lacustrine deposits and morainal deposits show the influence of glacial activity. The drift has an average thickness of approximately 150 feet throughout the county.

A study of well logs shows the presence of Devonian shales underlying the southwestern half of the county and rocks of Mississippian age underlying the northeastern half of the county. Of course it is understood that local variation might occur with respect to the upper bedrock in that preglacial erosion may have removed the strata in a given spot. The upper surface of the Trenton limestone lies at an elevation of about 350 feet below sea level in the southwestern part of St. Joseph County and descends to about 900 feet below sea level in the northeastern part of the county.

General Geological Section for St. Joseph County

Quaternary:
Recent,-- sands, clays and gravels . . . . . 0- 40'
Pleistocene, -- sands, clays and gravels . . . . . 0-200'
(NO OUTCROPS OF BEDROCK).
Mississippian: shales and sandstones, limestones . . . .Thickness unknown
Devonian: shales and limestones . . . . . "

Section of combination well at Studebaker plant, South Bend, from Water Supply Paper 254 (page 208), by S. R. Capps.

Sand and gravel	32'
Coarse gravelly sand	8
Coarse sand, finer than that above	12
Rather fine angular sand	5
Coarse gravelly sand	4
Fine sand	4
Sandy blue clay	11.
Fine blue clay	14
Fine quicksand	4
Sandy gravel	9
	109

Log of deep gas well drilled near Studebaker Plant, South Bend From Water Supply Paper 254 (208), by S. R. Capps.

Drift	160'
Subcarboniferous and Hamilton shale	220
Corniferous limestone	60
Lower Helderberg limestone	40
Niagaran limestone	640
Clinton (?) limestone	60
Hudson River and Utica	420
Trenton limestone	427
	2,027

The section of a well in South Bend, construction from drilli furnished Phinney by J. D. Oliver is as follows:

Drift sand and gravel	137'
Waverly shale (bluish-green, calcareous)	143
Black shale	70
Brown shale	25
Gray limestone (Upper Helderberg)	60
Blue limestone	20
Lower Helderberg, with gypsum	170
Water, lime	55
Niagara limestone (gray, buff and white)	470

Buff Clinton limestone	30'
Hudston River limestone and shale	220
Utica sand	183
Trenton limestone (chocolate colored)	85
	1,670

Salt water was encountered at 375, 610 and 1670.

Sources of Water Supply

Surface water supplies may be obtained in St. Joseph County from streams, springs and lakes. There are many lakes in the county which are capable of supplying water for domestic and industrial purposes.

Ground waters obtained from the glacial drift are, in most localities at least, potable and abundant. Waters from bed-rock formations are likely to be mineralized at greater depths. The deep well drilled at South Bend showed salt water occuring in the Devonian, and Ordovician strata. The Mississippian and Devonian shales are not aquifers.

Artesian wells occur in the lowlands along the St. Joseph River in the vicinity of South Bend.

Water Supplies of Towns in St. Joseph County

South Bend. -- (population 104,193, census of 1930) South Bend has a municipal water supply originating from 109 wells. Water occurs in the bedrock underlying the glacial drift which is 85 feet in thickness at South Bend. Water occurs in the wells from 80 to 178 feet. The wells are of different size, some 36 being cased with 6 inch casing, 3 with 8 inch casing; 36 with 10 inch casing and 34 with 12 inch casing. A large portion of the water supply comes from the horizon just above bedrock. This is a gravel which is capped with 20 to 40 feet of clay, thus making the source impervious to pollution and also assists in furthering artesian conditions.

Mishawaka. -- (population 28,630) Mishawaka owns its municipal water supply obtained from 37 wells which penetrate the sands and gravels. Water stands from 8 to 14 feet below the curb.

New Carlisle. -- (population 718) New Carlisle owns its public water supply obtained from 4 wells which produce water from the gravels at a total depth of 118 feet. Bedrock was not struck in these wells, according to the submitted records. The wells are located near the base of a moraine slope and are not as low topographically as they might have been, which perhaps accounts for their not reaching bedrock. The gravel from which the water comes is overlain by a blue clay which acts as a protective covering for the water supply.

North Liberty. -- (population 823) North Liberty obtains a good supply of water from 1 well drilled to a depth of 87 feet. The depth to bedrock is unknown, and the water comes from the gravels. The town owns the public supply.

Walkerton. -- (population 1137) Walkerton has a public water system which secures water from dug wells, 30 feet deep.

Osceola. -- (population 432) Osceola secures water from wells

25 to 30 feet in depth. The water is from gravels associated with the glacial drift.

Crumstown. -- (Unincorporated) Obtains water from wells 10 to 25 feet in depth. One well at a depth of 133 feet reported bedrock.

Lakeville. -- (population 522) The town of Lakeville has no public water system.

Typical Wells of St. Joseph County

Location	Depth	Quality	Quantity	Formation	Construction
T37N-R2E, Sec. 11	87'-116'	Hard	Abundant	Gravel	Drilled
T37N-R3E, Sec. 16	45- 60	"	"	"	Driven & Drilled
T35N-R1W, Sec. 24	20- 30	"	"	"	Driven
T38N-R1W, Sec. 34	100-198	"	"	"	Driven & Drilled
T35N-R1E, Sec. 33	35- 60	"	"	"	" "
T37N-R1E, Sec. 27	10- 25	"	"	Gravel-Rock at 133'	" "
T38N-R4E, Sec. 10	25- 50	"	"	Gravel	" "
Hamilton	10- 30	"	"	"	Dug, Driven
T36N-R2E, Sec. 34	30- 85	"	"	"	Driven & drilled
Lydick	20- 75	"	"	"	" "
T37N-R4E, Sec. 16	25- 30	"	"	"	" "
Polartown	10- 25	"	"	"	Dug- Driven
T38N-R1W, Sec. 36	10- 30	"	"	"	" "
Walnut Grove	90- 113	"	"	"	Driven & Drilled
T36N-R3E, Sec. 15	20- 110	"	"	"	" "
T36N-R3E Sec. 34	20- 120	"	"	"	" "
Wyatt	20- 120			Gravel	
Woodland	20 -110	"		"	
Walnut Grove	90- 113			"	
Terre Coupe	10-30'			"	
Polan Town	10-25			"	
Osceola	25-30			"	
Lydick	20-75			"	
Lakeville	30-85			"	
Hamilton	10-30			"	
Granger	25-50			"	
Crumstown	10-25			"	
	133			Rock	

MINERAL ANALYSES OF WATERS IN ST. JOSEPH COUNTY(145a)

(Parts per million)

Location	Geological Conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrate radicle	Color	Total Solids
Lakeville	Gravel		.03		43	36				307	48	3	.1	.001	2	364
Mishawaka	"	14	2.6		133	75	7.1		184		565	8.5				
Mishawaka	"		.2		152	44				317	238	39	4	.001	2	794
Mishawaka	"		.01		71	76				238	97	4	1.2	.001	9	394
New Carlisle	"				68	23		2.3	146		23	3.5				
NewCarlisle	"		.4		61	25				273	41	2	.01	.001	9	326
N. Liberty	"				69	27				289	112	36	.01	.001	2	462
Notre Dame	"				72	26				243	30	4		.001	2	236
Osceola	"		.1		89	24		1.6		213	70	43	1	.001		450
South Bend	"				87	27		3.7	157		40	14	44			
South Bend	"				159	58		6.3	135		399	57				
South Bend	"				68	23		4.2	138		32	9.7	Tr.			
South Bend	"			1	71	25	33		144		35	7.8	9.8			
South Bend	"		6.5		109	33			213		96	18				532
South Bend	"				76	28				247	39	24	1.5	.001		372
South Bend					57	34				218	10	7		.001	4	270
South Bend	"	13	.4		88	29		1.6		294	78	18	3.2			405
South Bend	"	14	3.8		45	22		7.7	6	210	25	3.2				242
Terre Coupe	"				48	12		3.2	86		23	5				
Walkerton	"			1	95	26		4.3	139		72	67	47			
Walkerton					89	30				254	73	19	4		2	612

(145a) (From Water-Supply Paper 254, U.S.Geological Survey, p. 213)

SULLIVAN COUNTY

GENERAL FEATURES

Area 460 aquare miles Population 28, 133 (Census of 1930)

Sullivan County is located in western Indiana. Its western boundary is the Wabash River, which is the Illinois-Indiana State lime. It is the fourth county north of the Indiana-Kentucky State line. Sullivan is the county seat.

Sullivan County is a part of the Wabash Lowland. Shannon (146) has described some of the physiographic features as follows:

(146)Shannon, C. W. Soil Survey of Sullivan County, 36th Annual Report of Department of Geology and Natural Resources, State of Indiana, 1911. pp. 231-249.

> "The surface of the county is principally level. Some broken country lies in the northeastern part and along the eastern side, but the rougher areas are along the streams; the sand hill regions present an undulating surface. The stream valleys are wide, and about one-fifth of the county is occupied by the flood plains and terraces At Merom the river bluff has a height of about 170 feet. Here and at the narrows in Sec. 25, T. 9 N., Range 11 West, the river flows directly along the bluff. Below Merom the Wabash valley is from two to four miles wide, the terrace is made up largely of gravel; above Merom the valley is from one and a half to three miles wide and the terrace is quite sandy."
>
> "The coal measures are the only geological formations represented in the surface rocks of the county. The rocks are everywhere, except along the stream, covered with drift or loess to a depth of 10 to 50 feet or more. The eastern part of the county is more broken than the central or western and the soils are thin and poor."

Drainage. -- The drainage of the county belongs to the Wabash system. The Wabash forms the western boundary of the county. Most of the streams in the county drain directly to the Wabash. In the southeastern corner of the county, water goes to the West Fork of White River, then to White and ultimately the water reaches the Wabash.

A small area in the northwestern part of the county is drained by Prairie Creek which enters from Vigo County. Turmans Creek drains a part of the northwestern portion. Turtle Creek and Little Turtle Creek are branches of the Wabash which drain the western part of the county.

The larger part of the county is drained by Busseron Creek and its tributaries. Busseron Creek rises in the southeastern part of Vigo County and flows in a southwesterly drieotion to the Wabash.

GEOLOGY

The unconsolidated deposits of the county consist of glacial drift, alluvium, and residual soils. The sand hills have been formed by the wind acting on stream deposits. Where the drift and alluvium is thicker than 10 or more feet, ground water may be obtained readily.

Some of the thick deposits of alluvium and drift appear to have been laid down in old stream channels. Much drilling has been done in the county in the search for oil and gas and in prospecting for coal.

The bedrock formations of the county are of Pennsylvanian age. The Allegheny series and post-Allegheny series are represented. The Allegheny series formations occur along the eastern border of the county. They occur in a creek valley some two to three miles east of Sullivan, which is their westernmost outcrop. Most of the county is underlain by post-Allegheny formations. The bedrock consist of sandstones, limestones, shales, coals, and underclays.

Generalized Geologic Section for Sullivan County

Quaternary:
- Recent, -- chiefly alluvium . . . . . 0- 50'
- Pleistocene, -- . . . . . 0-100'

Pennsylvanian:
- Post-Allegheny
- Allegheny
- Pottsville, -- (Does not outcrop in county)

Sources of Water Supply in Sullivan County

Surface water supplies in Sullivan County are obtained from lakes, streams, and springs. The supplies may be augmented by the impounding of water in stream courses and on the water sheds of streams.

GROUND WATER

Ground water may be obtained from a number of stratigraphic horizons. The alluvial deposits in the valley flats furnish large quantities of water. The glacial drift is quite important as an aquifer, where it is more than a thin mantle. Wells have recorded gravels a few feet below the surface, which bear water. Some of the Pennsylvanian formations bear potable supplies. The sandstones and coals are especially good aquifers. Some mineralized waters occur in the coal-bearing areas.

Water Supplies of Towns in Sullivan County

Farmersburg. -- (population 993) The town of Farmersburg owns its water system. The supply is obtained from tubular wells.

Sullivan. -- (population 5,306) The Sullivan County Water Company supplies the city of Sullivan with water. The supply is obtained from a dug well.

The following towns in Sullivan County do not have public water systems:

Dugger. -(population 1,383); Shelburn. -(population 1,548); Merom. -(population 397); Carlisle. -(population 852); Hymera. -(population 1,152).

This information is obtained from the 1932 report of the Indiana State Board of Health. The above towns are not listed.

SWITZERLAND COUNTY

GENERAL FEATURES

rea 222 aquare miles Population 8,432 (Census of 1930)

Switzerland County is in the extreme scutheastern corner f Indiana, having the Ohio River for its eastern and southern oundaries.

The maximum altitude of Switzerland County is 850 feet bove sea level and the minimum elevation is 415 feet, thus giving 35 as the maximum relief. The maximum local relief is 405 feet.

Along the Ohio River there are some level bottom lands, nd a small amount of valley floor along the lower courses of some f the smaller streams. All the remainder of the county is hilly nd some parts are locally considered as mountainous. There are o large streams in Switzerland County, but the proximity of the hio River gives to these minor streams a tremendous fall and cutting ower. They have cut out deep gorges through the soft rocks and in ocations near the Ohio or near the mouths of these streams, the g orges are as much as 350 feet in depth and the sides very precipitous. small area of level land is found near East Enterprise and near llensville and also in the northwest corner of the county.

Drainage. -- This county lies within the Ohio River rainage basin. The Ohio River forms the southern and eastern oundaries of the county. The northern part of the county is rained largely by short branches of Laughery Creek. The most import- nt of these are South Fork and Bear Creek. Branches of Kentucky reek, Brush Fork and Middle Fork drain an area in the northwestern art of the county. Indian Creek and its branches, Long Run and endleton Run, drain an area in the southern part of the county. lum Creek, Log Creek, Hunt Creek, and Bryant's Creek are other short ranches of the Ohio River, draining an area in the southern part f the county. Grant's Creek drains an area in the northeasten part f the county and flows into the Ohio River.

GEOLOGY

The unconsolidated deposits of Switzerland County consist f glacial debris and alluvial deposits. The latter are located long the Ohio River and in the lower courses of a few larger streams ome alluvial deposits of fluviatile orgin are found.

The glacial deposits occur on the uplands and vary in hickness. The entire county was covered by the Illinoian glacial. he later or Wisconsin glacier did not come this far south. The hio River valley is a preglacial valley and 118 feet of material as penetrated at Vevay before solid bedrock was struck. The present hio River is entrenched in the glacial and alluvial materials.

The bedrock formations of Switzerland County consist of rata of Ordovician age with the exception of an outlier of Silurian rata in the extreme northwestern portion of the county.

Glacial drift covers the bedrock in many places, however, rosion has removed the glacial mantle in many places, especially ong drainage courses.

Ground water may be obtained from a number of formations including the Recent sands and gravels, the Pleistocene sands and gravels and the Ordovician limestones. The upper strata contain potable waters. The lower strata contain mineral waters known as "blue lick" waters. Rocks of Trenton age and older contain mineral water.

Sources of Water Supply

Surface waters may be obtained from springs and streams in Switzerland County. Some waters are impounded by the constructi of reservoirs on streams and water sheds.

General Geological Section for Switzerland County

Quaternary:
- Recent,-- sands and clays . . . . . 0- 20'
- Pleistocene, -- clays, sands and gravels. . 0- 60'

Silurian: limestones . . . . . 0- 50'

Ordovician:
- Cincinnatian, --limestone 175
- Trenton-Mohawkian, -- limestone 216

Water Supplies of Towns in Switzerland County

Vevay, -- (population 1, 183) Vevay obtains a supply of water from the Ohio River. The city owns the system.

Patriot. -- (population 288) The town of Patriot has no public water system.

Moorefield. -- (population 84) The town of Moorefield has no public water system.

Typical Water Supplies of Switzerland County

Township and Section	Quality	Depth	Formation
Cotton			
Mellville	----	20'	Shale
NW¼ 1-2-3W	----	22	---
NW¼ 6-2-2W	----	24	---
Allenville	----	15-20	---
East Enterprise	----	10-20	Shale
SW¼ 2-2-2W	----	30	---
NE¼ 12-2-3W	----	12	---
Craig			
SE¼ 16-2-3	----	20	Blue Clay
Longrun	----	23	---
NW¼ 7-2-3W	Soft	--	Cistern
SW¼ 6-2-3W	Hard	22	Limestone
SE¼ 36-3-4W	----	32,33-25	---
Jefferson			
NW¼ 22-2-3W	----	65	---
NW¼ 8-1-2W	----	57	---
NW¼ 3-1-2W	----	48	---
SW¼ 4-1-2W	----	55'	---
SE¼ 7-1-2W	Soft	--	Cistern
SE¼ 7-1-2W	Hard	43	Gravel
SE¼ 12-2-3	----	65	---
NW¼ 12-2-3	----	72	---
Vevay	Hard	86-96	Gravel

Township and Section	Quality	Depth	Formation
Pleasant			
Moorefield	----	25-34,125	Clay
NW¼ 3-4-12E	Soft	---	Cistern
SW¼ 34-5-12E	"	---	"
NE¼ 33-5-12E	"	---	"
NE¼ 28-5-12E	Hard	82	Limestone
SW¼ 22-5-12E	---	20	---
Pleasant	---	26	Limestone-cistern
SW¼ 15-5-12E	Soft	---	Cistern
NE¼ 23-5-12E	---	20	---
NE¼ 23-5-12W	Hard	23	Limestone
Bennington	"	20-25	"
SE¼ 32-3-3W	---	12	Shale
NW¼ 4-2-3W	---	25	"
Fairview	Hard	25	Limestone
Posey			
Quercus Grove	---	20-30-72	---
NW¼ 8-2-1W	Hard	18	---
SE¼ 4-2-1W	Soft	---	Cistern
SE¼ 3-2-1W	"	---	"
NE¼ 11-2-1W	"	---	"
SE¼ 11-2-1W	---	12	---
NE¼ 7-3-1W	Soft	---	Cistern
SW¼ 5-3-1W	---	28	---
SE¼ 30-3-1E	Soft	---	Cistern
SW¼ 29-3-1E	"	---	"
NW¼ 32-3-1E	---	68	---
SE¼ 32-3-1E	Hard	112	Gravel
NW¼ 5-2-1E	Soft	---	Cistern
NW¼ 8-2-1E	---	49	---
NE¼ 7-2-1E	Soft	---	Cistern
Patriot	Hard	60-65	Gravel
NW¼ 24-2-1W	Soft	---	Cistern
NE¼ 23-2-1W	---	32	Shale
SE¼ 22-2-1W	Hard	47	Gravel
NE¼ 27-2-1W	---	32	Shale
York			
SE¼ 28-2-1W	---	28	---
Florence	Hard	20-25	Gravel
NW¼ 2-1-2W	---	60	---
Markland	Hard	55-66	Gravel

TIPPECANOE COUNTY

GENERAL FEATURES

Area 503 square miles. Population 47,535 (Census of 1930)

Tippecanoe County is situated in the west central part of Indiana. It is the second county east of the Indiana-Illinois State line and the fourth county south of Lake Michigan. Lafayette is the county seat.

The maximum elevation in the county is 840 feet above sea level, the minimum is 495 feet, thus giving a total maximum relief of 345 feet. The maximum local relief is 185 feet. Tippecanoe County lies wholly within the drainage basin of the Wabash. Along the margin of the Wabash and its principal tributaries the surface is generally broken and hilly, while back from these streams the topography of the county is slightly undulating and rolling, gradually extending into plains or level tracts. In the southern half of the county are a number of gravelly ridges of morainal drift, some of which are isolated. The eastern central part of the county has two or three morainal remnants, likewise the northwestern portion. The moraines seldom exceed fifty feet in height. The most conspicuous topographic feature of the county is the valley of the Wabash. It has a depth of more than 100 feet, with a gradual rise to the northwest and southeast.

Drainage. -- The drainage of Tippecanoe County belongs to the Wabash system. The Wabash River crosses the county from the northeast corner to near a central point on the western boundary. It receives the waters from two main tributaries in the northeastern part of the county, from the Tippecanoe River on the north and from Wild Cat Creek on the east.

Northern branches of the Wabash which drain the northwestern part of the county are Burnetts Creek and Indian Creek. Sugar Creek and Buck Creek are two eastern branches of the Wabash which drain an area in the northeastern part of the county. Wild Cat Creek has two southern branches, Middle Fork and South Fork which drain an area in the southeastern portion of the county. Big Wea and Little Wea drain a part of the southern portion of the county. Shawnee Creek drains an area in the southwestern part of the county.

GEOLOGY

The unconsolidated deposits of Tippecanoe County consist of alluvium on flood plains, terraces of the Wabash River, glacial drift and residual soils.

Along the valley of the Wabash there are gravel terraces reaching a height of nearly 100 feet above the stream. The most conspicuous are located below Lafayette, where they are named, Wea Plains. They are present at Battle Ground, up the river from Lafayette. Leverett states that wells on the terraces of the Wabash near Battle Ground usually obtain no water within 50 feet of the surface, and in some instances are put down to a depth of 60 or 80 feet. A log of a well two miles west of Battle Ground is

given in Water Supply Paper No. 21, U. S. Geological Survey.

Soil and yellow clay	30'f
Dry sand	20'
Blue clay	30'
Cemented gravel	2'
Loose gravel	13'
Total	95

This well was on the uplands, where water is usually obtained at about 20 or 30 feet.

Well borings have proved the presence of some deeply filled valleys buried below the drift. The irregularities of the surface before the glacial materials were deposited account for the variations in depth to solid bedrock.

The glacial drift varies in thickness. Both ice sheets covered the area, and the drift ranges from outcrops of bedrock with a few inches of drift to 300 feet of deposits.

The bedrock strata of the county are of the Devonian and Mississippian systems. The Devonian shale underlies the drift in the northeastern one-fourth of the county and the Borden group of the Mississippian occupies the remainder of the county.

Generalized Geologic Section for Tippecanoe County

Quaternary:	
Recent, -- chiefly alluvium	0- 50'
Pleistocene, --	0-300'
Mississippian:	
Borden, -- shales and siltstones --(Thickness unknown)	
Rockford, -- limestone	2- 5'
Devonian:	
New Albany, -- shale (Thickness determined from well records)	100-125'
Devonian, -- shale (Thickness unknown, no exposures)	
Silurian: (Not exposed)	

GROUND WATER

The unconsolidated deposits of this county are the source of practically all the ground water in use. The bedrock consist of New Albany shale and Borden siltstones and shales. They are not aquifers. Little is known about the deeper Devonian and Silurian limestones. They bear water but usually are mineralized when se several miles from the outcrop down dip.

The glacial drift, the terrace deposits, the flood plains, and outwash materials are the sources of ground water. Gravel is given as the aquifer in 32 out of 34 wells, about which inquiry was made.

Water Supplies of Towns in Tippecanoe County

Lafayette. -- (population 26,240) Lafayette owns its water system. Fourteen wells produce water from gravel of the Wabash valley. Springs along the river bluffs indicate movement of considerable water toward the river.

West Lafayette. -- (population 5,095) The West Lafayette Water Works Co. supplies the city of West Lafayette with water. Fifteen wells averaging some 90 feet in depth produce the supply. A trace of iron is present in the water.

Battle Ground. -- (population 448) The town of Battle Ground owns its water system. Two wells, approximately 75 feet in depth furnish the supply from gravel.

Clarkshill. -- (population 428) The town of Clarkshill has no public water supply.

Typical Wells of Tippecanoe County

Location	Depth	Quality	Quantity	Formation	Construction
T24N-R3W					
Sec. 23	43'	Hard	Good	Sand & Gravel	Driven
Sec. 36	30	"	"	Gravel	"
Sec. 22	20-115	"	"	"	Driven & Drilled
T22N-R5W					
Sec. 18	30-70	"	"	"	Driven
Sec. 31	20-160	"	"	"	Dug & Drilled
Sec. 34	20-100	"	"	"	" "
T23N-R3W					
Sec. 7	17	"	"	"	Dug
T24N-R4W					
Sec. 23	85	"	"	"	Drilled
Sec. 24	65	"	"	"	Driven
Sec. 35	35-40	"	"	"	"
T23N-R5W					
Sec. 3	30-100	"	"	"	"
Sec. 11	35	"	"	"	Drilled
Sec. 28	30	"	"	"	Driven
Sec. 35	40	"	"	"	"
Sec. 6	25-60	"	"	"	"
Sec. 30	54	"	"	"	"
T21N-R6W					
Sec. 3	60	"	"	Limestone	Drilled
Sec. 6	78	"	"	"	"
Sec. 32	80-120	"	"	Gravel	"
T22N-R4W					
Sec. 20	81	"	"	"	Driven
Sec. 31	40	"	"	"	Drilled
T21N-R4W					
Sec. 22	63	"	"	"	"
Sec. 20	30-40	"	"	"	"
	(3 Wells 103'-- no water (Romney).				
T24N-R3W					
Sec. 36	30	Good	Fair	Gravel	Dug
Sec. 33	18-25	"	Good	"	"
T23,R3W					
Sec. 10	15-20	"	"	"	Driven
Sec. 16	103	"	"	"	Drilled
Sec. 21	15-20	"	"	"	Flowing
Sec. 28	36	"	"	"	Drilled
T22N-R3W					
Sec. 9	25-100	"	"	"	"
Sec. 22	112	"	"	"	"

Typical Wells of Tippecanoe County (Cont'd)

Location	Depth	Quality	Quantity	Fromation	Construction
T21N-R3W					
Sec. 10	25-30	Good	Good	Gravel	Driven
Sec. 14	25	"	"	"	"
Sec. 17	110	"	"	"	Drilled

TIPTON COUNTY

GENERAL FEATURES

Area 260 square miles Population 15,208 (Census of 1930)

Tipton County is located in the north-central part of Indiana, 30 miles north of Indianapolis.

The maximum altitude of Tipton County is 930 feet above sea level, the minimum altitude is 815 feet, thus giving a total maximum relief of 115 feet. The maximum local relief is 40 feet, which is the lowest in the State of Indiana. Tipton County is typical of that great physiographic unit known as the Tipton Till Plain, which occupies the central portion of Indiana. The surface of the county is gently undulating, however, it is a typical upland area. The county lies on the divide between White River and Wabash River drainages, the watershed is a flat, featureless plain. A small area bordering Hamilton County is slightly rolling, however, most of the county consists of ground moraine with the crests and troughs very shallow.

Tipton County lies partly within the Wabash drainage basin and partly within the White River system. Wild Cat Creek and its branches drain an area in the northern part of the county. Wild Cat Creek has two southern branches, Irwin Creek and Prairie Creek. Its principal western branch is Mud Creek and its branch, Broad Creek. Swamp Creek and its branch, Shanty Creek, drain a part of the western portion of the county.

The southern portion of the county is drained by Cicero Creek and its branches into White River. The western and northern branches of Cicero Creek are Devil's Den Run, Prairie Creek, Wallace Creek, Jerico Creek, Nixon Creek and Wolf Creek. The southeastern part of the county is drained by Duck Creek and its branch, Polliwog Creek.

GEOLOGY

The unconsolidated deposits of Tipton County consist of alluvial and glacial deposits. The alluvial deposits occur as shallow flood plains along the major streams. Cicero Creek has a valley flat in which wells have obtained water, however, most of the streams are so small that the alluvial deposits are of limited areal extent.

The glacial deposits consist of ground moraine and till plain. The morainal area has slightly greater relief and occupies the western edge of the county. The very northwestern corner of the county has some morainal area. The till covers most of the county and varies in thickness from 40 to 75 feet along the north and east margins and becomes thicker toward the south and west. Dug wells are used in the till areas and many supplies come from the clayey till.

The bedrock strata underlying the till of Tipton County consist of rock of Silurian and Devonian age. The Silurian strata occupy the eastern and central parts of the county and the Devonian strata are found underlying the glacial deposits in the western quarter of the county. The Devonian rocks underlie that portion of the county west of a line extending from the northwest corner of the county to the southeastern corner of Jefferson Twp. The bedrock dip at low angles to the west. No outcrop of bedrock occur within the county. The Silurian strata produce an abundance of good water where penetrated. The water comes from limestones. The Devonian is

overlain by thicker drift, however, these Devonian limestones usually carry excellent supplies of ground water.

General Geological Section for the County

Quaternary:	
Recent, -- sands, clays and gravels	0- 40'
Pleistocene, -- sands, clays and gravels	0-150'
Devonian: limestones	0- 60'
Silurian; limestones	300'
Ordovician: limestone and shales (Cincinnatian) -- (Determined from well logs)	424'
Ordovician: limestone (Trenton-Mohawkian)	30'

Sources of Water Supply

Surface water supplies may be obtained in Tipton County from streams and springs. Additional supplies of surface water may be obtained by the impounding of water in streams and on water sheds.

Ground water may be obtained from a number of geological horizons. The Recent and Pleistocene deposits carry potable supplies of ground water. Also the bedrock formation immediately underlying the glacial drift bears good ground water. The Ordovician strata at still greater depths bear mineralized water. Many wells drilled for natural gas or oil penetrated Trenton strata, bearing salt water.

Deeper formations have not been tested in this county, however, it is likely that water from these deeper formations would be highly mineralized and unfit for domestic purposes.

Water Supplies of Towns in Tipton County

Tipton. -- (population 4,861) Tipton owns its waterworks which secures a supply of water from five wells. The water is derived from the limestones and shales underlying the glacial drift. Bedrock is found at a depth of 110 feet. Water rises to within 50 feet of the surface in the wells. Private wells obtain supplies of water from the water-bearing gravels at depths from 30 to 100 feet. In most cases the gravels bearing the water are over lain by impervious clay thus protecting the supply from contamination.

The following towns do not maintain public water supplies:
Kempton. --(population 469)
Sharpsville. --(population 512)
Windfall. -- (population 734)

Typical Wells of Tipton County

Location	Depth	Quality	Qauntity	Formation	Construction
T21N-R4E Sec. 2.	68-114	Hard	Abundant	Gravel-Limestone at 165'	Drilled
T22N-R5E Sec. 10	20- 80	"	"	Gravel & limestone	Driven & drilled

Location	Depth	Quality	Quantity	Formation	Construction
T22N-R3E Sec. 5	20-100	Hard	Abundant	Gravel & Limestone	Driven & drilled
T21N-R3E Sec. 6	35-200	"	"	Gravel-Limestone 265'	Driven & Drilled
T22N-R6E Sec. 31	20- 90	"	"	Gravel-Limestone at 90'	Driven & drilled
T21N-R3E Sec. 35	20- 60	"	"	Gravel Limestone at 240'	Driven & drilled
T21N-R3E Sec. 2	15-120	"	"	Gravel	
T22N-R3E Sec. 16	25- 40	"	"	Gravel-Limestone at 120'	Driven & drilled
T21N-R5E Sec. 10	13- 65	"	"	Gravel-Limestone at 180'	Driven & drilled
T22N-R4E Sec. 27	18-160'	"	"	Gravel & Limestone	Driven & Drilled
T23N-R5E Sec. 31	15-130	"	"	Gravel & Limestone	" "
T21N-R6E Sec. 19	20- 60	"	"	Gravel & Limestone	" "
T22N-R3E Sec. 35	15-280	"	"	Gravel & Limestone at 300'	" "
Tetersburg	20-125	"	"	Gravel-Limestone at 190'	" "
Tipton	68-114 165	"		Gravel Limestone	Five wells
Windfall	20- 30 60- 80			Gravel Limestone	
Sharpsville	20- 80 68-100			Gravel Limestone	
Kempton	35-200 265			Gravel Limestone	
Curtisville	20- 90 90			Gravel Limestone	
Elkin	20- 60 240			Gravel Limestone	
Goldsmith	15-120			Gravel	
Groomsville	25- 40 120			Gravel Limestone	
Hobbs	13- 65 180			Gravel Limestone	

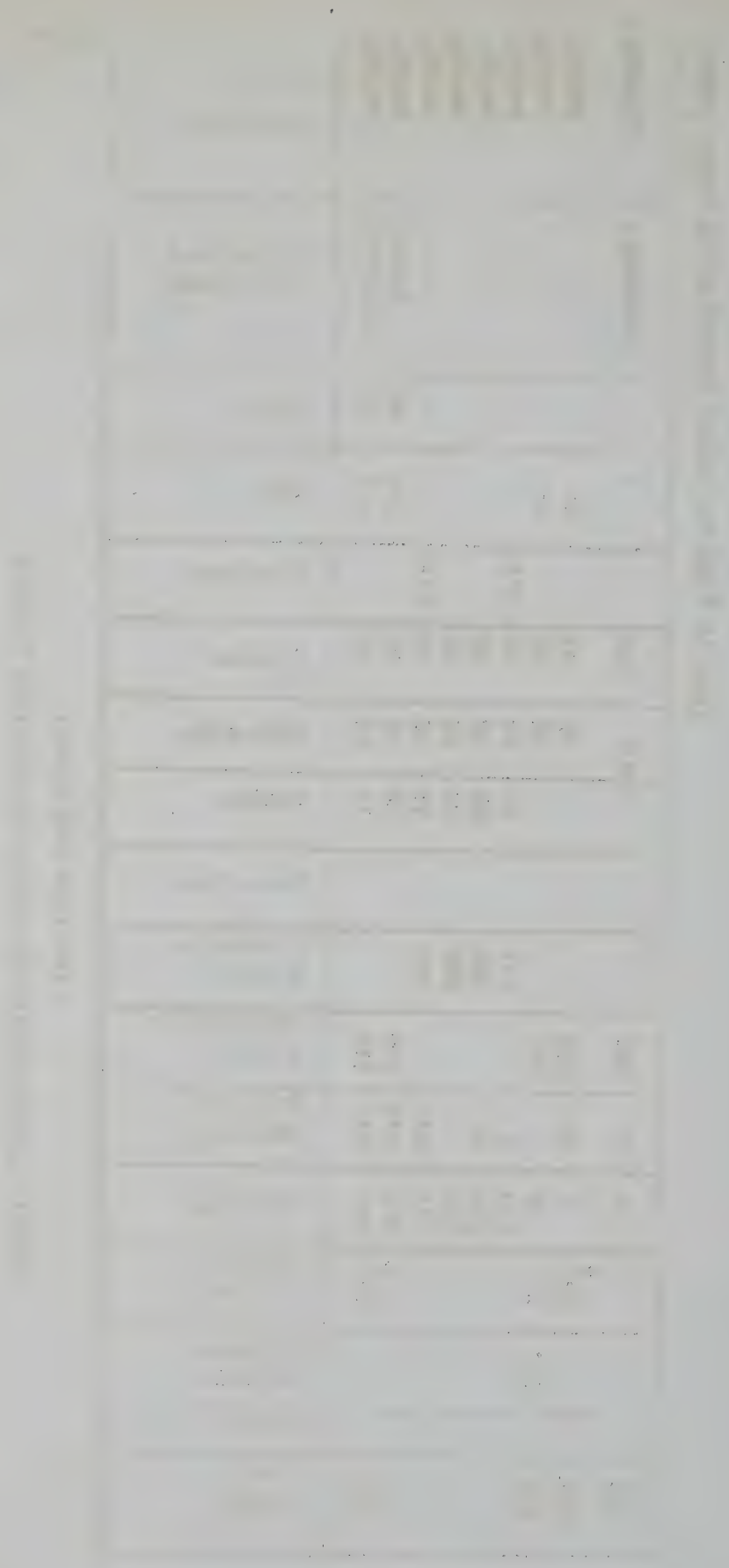
Location	Depth	Quality	Quantity	Formation	Construction
Jackson	18- 90			Gravel	
	90-160			Limestone	
Nevada	15- 50			Gravel	
	50-130			Limestone	
New Lancaster	20- 50			Gravel	
	50- 60			Limestone	
Normanda	15-280			Gravel	
	300			Limestone	

MINERAL ANALYSES OF WATERS IN TIPTON COUNTY (146a)

(Parts per million)

Location	Geological Conditions	Silica	Iron	Aluminum	Calcium	Magnesium	Sodium	Potassium	Carbonate Radicle	Bicarbonate Radicle	Sulphate Radicle	Chlorine	Nitrate Radicle	Nitrite Radicle	Color	Total Solids
Tipton	Limestone	25	1.7		73	15	31			411	1.3	5.4	4.2			350
Tipton	Gravel	26	4.3		76	28	20			402	4.4	7.8	4			349
Tipton				9.8	88	25	24		216		6.8	5.6				
Tipton					69	29	23		202			6.1				
Tipton					93	25	28		210		32	7.3				
Tipton				2.0	70	27	23		195		1	6.7				
Tipton			.6		71	25				348		8	.3	.001		372
Tipton			.6		19	30				403	21	5	.4			442
													5			
Windfall	Limestone		1		83	7.6				400	51	20				464

(146a) (From Water Supply Paper No. 254, p. 220)



U N I O N C O U N T Y

GENERAL FEATURES

Area 162 square miles Population 5,880 (Census of 1930)

Union County is situated in eastern central Indiana. Its eastern boundary is the Indiana-Ohio State line. It is third county north of the point where the Ohio River first touches Indiana. Liberty is the county seat.

The maximum altitude in the county is 1,130 feet above sea level the minimum is 680 feet, thus giving a total relief of 450 feet. The maximum local relief is 250 feet. The county is a part of the Dearborn-Upland.

"The topography in the eastern and western halves of Union County varies greatly. Immediately east of a line drawn due north and south through Liberty is a slightly rolling surface, becoming more and more level farther east until a distance of three miles is reached. East of this we find a gently undulating plain containing rather extensive areas of the dark colored soils. This topography is due largely to glaciation. Although the surface west of this line, which passes through Liberty, is also covered by the Later Wisconsin drift, yet the surface features are mainly due to erosion. The valley of the East Fork of Whitewater River, which traverses the western quarter of the county from north to south, has a depth of more than 100 feet, while the valleys of Hannahs, Silver and Richland Creeks, which join it on the west, and Ellis, Turkey, and Simpson, on the east, are 50 feet below the adjacent uplands. In preglacial times the valley of the East Fork was 200 feet deeper than today. This has been learned by borings which have gone down through 200 feet of fluvial material before reaching the bed rock.

"An older drift seems to underlie the Later Wisconsin, as was apparent when a well at Liberty, below the till formation at a depth of 35 feet, passed through a bed of swamp muck, containing leaves. A similar experience was met two miles south of Brownsville, where a well passed through swamp muck below gravelly drift at 20 or 30 feet. These indicate a glacial topography overridden by the Later Wisconsin ice sheet. The combined thicknesses of the two drifts are from 20 to 40 feet on the upland." (147)

(147) Taylor, A. E., Soil Survey of Union County, 34th Annual Rept. Indiana Dept. of Geology and Natural Resources, 1909. pp.106-113.

Drainage .-- Union County lies within the Whitewater River basin. The East Fork of Whitewater River flows from north to south through the western part of the county. Whitewater River receives three tributaries from the west, Simpson, Turkey, and Ellis Creeks. The tributaries on the east are Richland, Silver, Hannahs and Dubois Creeks. The eastern part of the county is drained by Four Mile Creek. The southeastern part is drained by Templeton Creek.

GEOLOGY

The unconsolidated deposits of Union County consist of glacial drift, valley train materials, flood plain deposits and residual soils. The county was covered by the two glacial invasions.

On the uplands the drift is not thick, usually between 20 and 40 feet. In the river valleys the gravel deposits in places are as much as 200 feet. The valley flat areas are not extensive but locally are important as sources of ground water.

Ordovician and Silurian strata underlie the drift and in places outcrop in Union County. About twenty square miles of Silurian occur in the northeastern corner of the county.

Generalized Geologic Section for Union County

Quaternary:	
Recent	0- 25'
Pleistocene, -- glacial drift, valley train gravels . .	0- 50'
Silurian:	200
Ordovician:	600

SOURCES OF WATER SUPPLY

Surface supplies of water may be obtained in Union County from streams and springs. Cisterns are used where supplies cannot be obtained in wells of reasonable depth.

Ground Water .-- The glacial drift, valley trains, and flood plain deposits are the chief sources of ground water within the county. Usually the drift is of sufficient thickness to warrant adequate supplies. The valley train deposits along the streams contain an abundance of water.

The bedrock formations bear some water, though the Ordovician limestones are not aquifers. Portions of the bedrock when adjacent to drift or other unconsolidated deposits usually are porous and wells need only penetrate the bedrock for a few feet.

Natural springs are plentiful in the county.

Water supplies of towns in Union County

Liberty . -- (population 1,241) The city of Liberty owns its water supply, which is obtained from tubular wells, Two wells which penetrate bedrock at 90 feet furnish the supply. The water level is at 56 feet. The wells are 10 inches in diameter. Iron and sulphur have been noted in the water.

V A N D E R B U R G H C O U N T Y

GENERAL FEATURES

Area 233 square miles Population 113,320 (Census of 1930)

Vanderburgh County is situated in southwestern Indiana. Its southern boundary is the Ohio River and Indiana-Kentucky State line It is the second county east of the Wabash River, which is the Indiana-Illinois State line. Evansville is the county seat.

The maximum altitude of the county is 600 feet above sea level, the minimum is 321 feet, thus giving a total maximum relief of 279 feet. The county is a part of the Wabash Lowland. The Ohio River bottoms are from two to five miles wide, also Pigeon Creek and other streams have wide valley flats in their lower courses. The northern part of the county is fairly level uplands, being 150 to 350 feet above low water on the Ohio. The maximum local relief is 140 feet.

Drainage. -- The surface waters of Vanderburgh County are in part carried to the Ohio and in part to the Wabash. Pigeon River enters the county from the east and flows in a southwesterly direction to enter the Wabash at Evansville. Several small tributaries of this stream drain the central part of the county. Big Creek and its branches drain the western and northern portions of the county. Bayou Creek drains an area in the southwestern part of the county.

GEOLOGY

The unconsolidated deposits of Vanderburgh County consist of alluvial materials, loess, glacial drift and lacustrine deposits. The Ohio River has a wide valley flat known as the lower or first bottoms which is subject to overflow. Alluvium also occurs along the smaller streams. The South Fork of Big Creek and other streams have in their upper valleys deposits of older silts. The deposits are thought to be pre-Wisconsin in age. They consist of reworked loess with a clayey texture, but in places sandy and gravelly. The glacial drift in this county is very limited in areal extent. It is found only in the extreme northwestern corner. Southeast of the glacial margin in Vanderburgh County occurs some ten square miles of lake plain soils. There are two areas, one located in the northwest corner, along Flat Creek, and a smaller area about Stacer. The deposit consists of silt, fine gravel, and clay.

The bedrock strata of Vanderburgh County are of late Pennsylvanian age, post-Allegheny. They consist of sandstones, limestones, shales, coals and underclays.

Generalized Geologic Section for Vanderburgh County

Quaternary:
- Recent,-- chiefly alluvium . . . . . 0 -50'
- Pleistocene, -- lake and drift deposits . . . . . 0- 50'

Pennsylvanian: . . . . . 1100'
- Post-Allegheny, --
- Allegheny; --(Not exposed except in very southeastern corner of the county)

GROUND WATER

Vanderburgh County has extensive areas of valley flat land. Water occurs at shallow depths in these areas. Many wells obtain water from 20 to 40 feet. Occasionally compact clays in the bottom lands necessitate deeper drilling for adequate supplies. Usually ground water is readily obtained, unless on the outcrop of an impervious Pennsylvanian shale. The logs of wells drilled in the county for oil and gas show various water sands in the Pennsylvanian. Frequently mineralized waters occur in these formations. Wells which penetrate the underlying Mississippian or older formations will obtain mineralized waters.

Water Supplies of Towns in Vanderburgh County

Evansville. -- (population 102,249) Evansville owns its public water system. The supply is obtained from the Ohio River. The water is thoroughly treated before use.

V E R M I L L I O N C O U N T Y

GENERAL FEATURES

Area 254 square miles Population 23,238 (Census of 1930)

Vermillion County is situated in central western Indiana. Its western boundary is the Illinois-Indiana State line. It is the fifth county south of Lake Michigan. Newport is the county seat.

The maximum altitude of the county is 662 feet above sea level, the minimum is 460 feet, thus making a total maximum relief of 202 feet. The maximum local relief is 140 feet.

Coryell (148) has described certain features of the county

(148) Coryell, H. N., Soil Survey of Vermillion County, 38th Annual Report, Indiana Department of Geology and Natural Resources, 1913, pp. 72-73.

as follows: "Topographical features divide the county into three distinct regions: first, the alluvial soils and river bottom; second, the rolling lands; third, the prairies. The first of these is a narrow strip of land that follows the general meanderings of the river. At Clinton it is only a mile wide but gradually widens northward and again returns to the river just north of Hillsdale. Two miles south of Newport the bottom land is one and one half miles wide and retains that width northward to Little Vermillion River. North of this river it widens to two and one half miles. At Dickason the alluvial soils are three and quarter miles wide and are known locally as the Black Sand Prairie. One mile north of Perryville the terraces end. In the remaining sections northward the alluvial soil consists of only the river bottom deposits of a quarter of a mile or so in width. The Sioux, Wabash and Muck series constitute the soils of the first district and their description will be given in following papers."

"The second district lies to the west and adjacent to the first. It consists of the hilly and rolling land. This is spoken of as the upland soils, consisting of the Miami and Carrington series. The forests of Vermillion County grew principally upon these rolling uplands, of which a few wood lots remain, that barely give us more than an idea of the species of trees that composed these early forests."

"The third region lies to the west of the second and is not continuous throughout the county from north to south. In fact there are only two districts that make up this division; one lying about Dana in Helt Township and the other about Gessie in Highland Township. These are the prairie regions of Vermillion County, being the eastern limits of two of the lobes of the Illinois prairie, or Chicago prairie that project into Indiana. . . ."

Drainage. -- Vermillion County lies within the Wabash River drainage system. The Wabash forms the boundary for the eastern part of the county. Browns Creek, a tributary of the Wabash, drains the south part of the county. Spring Creek drains an area in the northern part of the county. Vermillion River crosses the

central portion and gathers the surface waters through several short tributaries in that part of the county. The Little Vermillion River and its branches gather the surface waters from the south-central part of the county.

GEOLOGY

The unconsolidated deposits of Vermillion County consist of alluvial soils of the bottom lands, river terraces, glacial drift and residual soils. The bedrock formations are of Pennsylvanian age. The post-Allegheny rocks are represented in the southwestern quarter of the county, the remainder is underlain by Allegheny rocks, with the exception of the bottoms of the Wabash, under which Pottsville rocks occur. The entire Pennsylvanian system is represented in the county. Coal has been important in this county for many years. Geological conditions necessary for the occurrence of natural springs are frequent in Vermillion County. There are many large springs along the river bluffs.

Generalized Geologic Section for Vermillion County

Quaternary:
- Recent, ... 0- 75'
- Pleistocene, ... 0-100'

Pennsylvanian:. . . . . 800'.
- Post-Allegheny, --
- Allegheny, --
- Pottsville, --

Mississippian: (Not exposed)

GROUND WATER

Water may be obtained in the river alluvium, terrace deposits glacial deposits and bedrock strata of Vermillion County. Leverett, in U. S. Geological Survey, Water Supply Paper No. 26, has given the following information on individual wells:

"On the till plain, in the northern part of the county, wells enter a blue till at about 6 or 8 feet, and obtain water in the beds of gravel or sand associated with the till at depths of 15 to 25 feet. There are very few deep wells, though the record of one 56 feet in depth was obtained. This is situated near the State line, in the northwest corner of the county, and is mainly through blue till.

"Wells on the gravel terrace of the Wabash, in the northern part of the county, are often sunk to depths of 60 or 80 feet, and occasionally 100 feet, through sand and gravel, before entering a water-bed. In passing westward from the river the gravel becomes shallower, and till is encountered before reaching the level of the river. It is not rare to find beds of muck containing wood and leaves at the base of the gravel. This muck is thought to be an interglacial flood-plain covered by glacial gravels of a later invasion.

"In the villages of Eugene and Cayuga, which are situated on a low terrace of the Wabash near the mouth of Big Vermillion River, wells are ordinarily obtained at 40 feet or less, at

about the level of the Wabash River.

"On the uplands west of Eugene, in Section 8, and at an altitude about 160 feet above the Wabash River, a boring 241 feet in depth failed to reach rock or obtain water. It was mainly a compact blue till.

"At Newport the wells range in depth from 12 to 88 feet, and obtain water in gravel between sheets of till.

"At Clinton wells are usually sunk to a depth of 60 to 75 feet in gravel, and obtain water at about the level of the Wabash River. A boring for coal at this village, made on the low bottom of the Wabash, penetrated 100 feet of drift before entering rock

"On the uplands, in the southern part of the county, wells are ordinarily obtained at about 30 feet, in gravel between till sheets."

The Pennsylvanian formation which underlie the county contain some water-bearing sandstones and coals, though in many instances the waters associated with coal are mineralized. Ground water, springs and surface supplies are now readily obtained so it is unnecessary to drill deep and expensive wells.

Water Supplies of Towns in Vermillion County

Clinton. -- (population 7,936) Clinton owns its water system. Nine wells drilled into the gravel deposits along the Wabash River furnish the supply. Water stands within seven feet of the surface. The wells are reported to be 26 inches in diameter.

Dana. -- (population 859) The town of Dana owns its water supply, obtained from a tubular well.

Cayuga. -- (population 968) The town of Cayuga owns its water supply, obtained from a tubular well.

Other towns in Vermillion County are as follows: Fairview Park (population 1,106); Universal (population 642); Perrysville (population 435); and Newport (population 777). According to present information these towns do not maintain public water systems.

V I G O C O U N T Y

GENERAL FEATURES

Area 409 square miles. Population 98,861 (Census of 1930)

Vigo County is located in central western Indiana. Its western boundary is the Illinois-Indiana State line. It is the sixth county south of Lake Michigan and the fifth county north of the Indiana-Kentucky State line. Terre Haute is the county seat.

The maximum altitude in Vigo County is 673 feet above sea level, the minimum is 440 feet, thus making a total maximum relief of 235 feet. The maximum local relief is 100 feet. The most prominent topographic feature of the county is the Wabash valley. It is from five to six miles wide and extends through the whole length of the county, forming the State boundary in the southern one-third of the county. Most of the present flood plain is from 14 to 20 feet above low water in the river. Between the flood plain and the bluffs there are fragments of a low terrace, which is either gravel or rock. The eastern two-thirds of the valley is occupied by a gravel terrace. The Wisconsin drift mantled a small area in the northwestern part of the county. Its margin is a moraine. The uplands east of the Wabash are fairly plane. They are mantled with Illinoian drift.

Drainage. -- Vigo County lies within the Wabash drainage basin. A small area in the southeastern portion of the county is drained by Splunge Creek, a tributary of the Eel River, and by another stream which flows into Sullivan County. Small streams also drain portions of the county through Sullivan County into the Wabash. Prairie Creek drains an area in the southwestern part of the county and enters the Wabash River. Browns Creek and Coal Creek drain an area in the northwestern part of the county into the Wabash. Eastern tributaries of the Wabash which drain the northeastern part of the county are Spring Creek and Otter Creek. Lost Creek and Honey Creek drain the east central part of the county and Honey Creek, a portion of the west-central part.

GEOLOGY

The unconsolidated deposits of Vigo County consist of glacial drift, river alluvium on terraces and flood plains, and residual soils. The alluvium of the first bottoms averages from 14 to 20 feet in thickness. The terraces stand at different heights above the river, one is approximately 35 feet, the other is about 60 feet. The glacial drift of the county varies in thickness from a thin mantle to as much as 150 feet.

The Pennsylvanian rocks which underlie the drift and which outcrop at various places in the county are of Pottsville, Allegheny, and post-Allegheny age. The Pottsville occur at the surface in the extreme northeastern corner of the county and occupy a small area. They dip to the westward and underlie the younger Pennsylvanian formations.

Generalized Geologic Section for Vigo County

Quaternary:	
Recent, -- chiefly alluvium	0- 50'
Pleistocene, ...	0-150'
Pennsylvanian:	1000'

GROUND WATER

The glacial drift is the chief source of ground water in Vigo County. Along the Wabash River sands and gravels extend 100 to 150 feet in depth. Water usually occurs in wells at or near the level of the river. Due to a lack of clay in the gravel many wells had to be abandoned for sanitary reasons, in the city of Terre Haute. The use of private wells in the city has not been recommended for years. Leverett has stated that the uplands west of the Wabash have drift varying in thickness from 10 feet or less up to more than 100 feet. The drift on the uplands east from the Wabash is generally but 20 to 40 feet in depth. It is probable, however, that tributaries of the Wabash, now obscured by the drift, have a filling of more than 200 feet. In the Wabash Valley borings at Terre Haute show a thickness of 150 feet of drift, the rock floor being nearly 100 feet below the bed of the present stream. Wells are usually obtained in the drift at depths of 20 to 40 feet or less, there being very few deep wells in the county.

It is usually unnecessary to penetrate the Pennsylvanian formations in the search for water supplies in this county. Some of the sandstones and coals are aquifers, though some of the water is unfit for use. The Pennsylvanian contains considerable thicknesses of shale beds which are impervious. Usually the farmer and home owner in the small community can not afford to drill a deep well, so cisterns or artificial reservoirs must be utilized, if the ground water is inadequate.

Water Supplies of Towns in Vigo County

Terre Haute. -- (population 62,810) The Terre Haute Water Works Corporation furnishes the city of Terre Haute with water. The source of supply is the Wabash River.

West Terre Haute. -- (population 3,588) West Terre Haute owns its public water system. Five wells drilled into sand and gravel furnish the supply. Water stands from 12 to 18 feet in the wells.

Riley. -- (population 260) and Seelyville (population 825) do not maintain water systems.

W A B A S H C O U N T Y

GENERAL FEATURES

Area 425 square miles Population 25,170 (Census of 1930)

Wabash County is located in north-central Indiana. It is the third county south of the Indiana-Michigan State line and the fourth county west of the Indiana-Ohio State line. Wabash is the county seat.

The maximum altitude of Wabash County is 930 feet above sea level, the minimum is 685 feet, thus making a total maximum relief of 245 feet. The maximum local relief is 120 feet. The valley of the Wabash passes through the county a little south of the center, and is the important topographic feature of the area. The northwestern and eastern portions of the county are morainal, the remainder is till plain. As a whole the county is a broad, rather level plateau, with the large Wabash trough cut into it.

Drainage. -- Wabash County lies partly in the Eel River and partly in the Wabash drainage areas. Eel River enters the county near the northwestern corner and flows diagonally through the upper third of the county. The branches which it receives from the north are Clear Creek, Silver Creek and Squirrel Creek. From the east it receives Paw Paw Creek and Bear Grass Creek.

The Wabash River receives from the north the waters of Kentners Creek and Lagro Creek. From the south it receives the Salamonie River, Treaty Creek and Mill Creek. The Salamonie River enters the county from Huntington County, and flows northwesterly to enter the Wabash a few miles from the eastern boundary of the county. The Mississinewa River crosses the southwestern part of the county and receives surface waters from the southern part of the county.

GEOLOGY

The unconsolidated deposits of the county consist of alluvium, glacial drift and residual soils. The only important alluvial deposits, along the bottom of the Wabash Valley, average less than one mile in width, though they are wider locally. Their thickness varies, but at Wabash they are approximately 60 feet. The Eel River and Mississinewa River have flood plain deposits which locally are of importance as water bearers.

The moraines northwest of Eel River consist of irregular knolls, ridges and kettles. Lakes occupy the larger depressions. The morainic materials run from 100 to 200 feet in thickness. The Mississinewa moraine extends northeastward and southeastward from Wabash to the county limits. These moraines are not as large as the moraines northwest of Eel River.

Till plains occupy about two-thirds of the surface of the county. The drift varies from a thin mantle to 400 feet in thick-

ness. A boring at LaFontaine penetrated 400 feet of drift. This was an old preglacial channel and has been traced southeastward into Grant County.

Wabash County is underlain by Silurian strata. The Liston Creek limestone underlies the drift over most of the county and the Mississinewa shale outcrops along the streams.

Generalized Geologic Section for Wabash County

Quaternary:

Recent, -- Chiefly alluvium . . . . . 0-60'
Pleistocene, ... 0-400'
Silurian:
Liston Creek, - - limestone . . . . . Total thickness unknown, 15-30'
Mississinewa, - - shale. . . . . Total thickness unknown

GROUND WATER

All the valley deposits of Wabash County carry abundant supplies of water. In many deposits of alluvium the water table is near the surface. The moraines and till plains are very important source of water. Dug wells are in use to obtain water from the more clayey portions of the moraines and till. In old pregracial channels ground water occurs in the gravel and sand associated with the till. Many drilled wells obtain water from the till, but better supplies are obtained from the bedrock.

The Silurian strata underlying the county are aquifers. The Liston Creek limestone which underlies the drift bears plentiful water. It is usually not necessary to penetrate the rock more than a few feet.

Water Supplies of Towns in Wabash County

Wabash. -- (population 8,840). The Northern Indiana Power Company furnishes Wabash with water. Tubular wells drilled into gravel and limestone are the sources of supply. Seventeen wells are in operation. Bedrock is penetrated at 98 feet, and water occurs at 65 feet in the wells. The water is hard with a trace of iron present. Many of the wells flow.

LaFontaine. -- (population 604). The town of LaFontaine owns its water system. One well drilled into coarse gravels is the source of supply. Bedrock occurs at 400 feet. The depth to water level is 30 feet.

North Manchester.-- (population 2,765). North Manchester owns its water system. Nineteen wells furnish the supply. Water level is 10 to 15 feet below the surface.

Roann. -- (population 395). Roann owns its water supply, which is obtained from one tubular well. Bedrock is penetrated at 105 feet in this locality. The town water supply comes from gravel.

Lagro. -- (population 467). The town of Lagro has no public water system.

Typical Wells of Wabash County

Location	Depth	Quality	Quantity	Formation	Construction
T29N-R5E, Sec. 23	50-60'	Good	Good	Gravel-Limestone at 100'	Drilled
Sec. 3	50-55'	"	"	Gravel	"
Sec. 26	30-100'	Hard	"	"	Driven and drilled
T29N-R6E, Sec. 5	100'	Good	"	"	Drilled
Sec. 2	70'	"	"	"	"
T29N-R7E, Sec. 5	----	----	----	------	-------
Sec. 6	----	----	----	------	-------
Sec. 15	30'	Good	Good	Gravel	Driven
Sec. 34	225'	"	"	Gravel 225' Limestone 225'	Drilled
Sec. 34	230'	Hard	"	Limestone	"
Sec. 34	230'	"	"	"	"
Sec. 3	20'	"	"	Gravel	Driven
Sec. 10	30'	"	"	"	"
Sec. 15	160'	"	"	Limestone	Drilled
T28N-R7E, Sec. 34	20-40'	"	"	"	Drilled 10' to rock
T27N-R7E, Sec. 3	96'	"	"	------	-------
T28N-R7E, Sec. 27	54'	"	"	Gravel	Springs
T27N-R7E, Sec. 3	15-20'	Soft	"	Sand	-------
Sec. 15	163'	Hard	"	Limestone	Drilled Drift 106'
Sec. 27	30-40'	Soft	"	Gravel	Driven
T26N-R7E, Sec. 11	25-60'	"	"	"	-------
Sec. 27	160'	Hard	"	Limestone	Drilled
Sec. 34	-----	----	----	Gravel	"
Sec. 28	80-120'	Soft	Good	"	Driven
Sec. 28	15-20'	"	"	"	-------
T27N-R6E, Sec. 27		Hard	Abundant	"	
T29N-R7E, Sec. 6	25-140'	"	"	"	Driven and drilled
T29N-R5E, Sec. 36	30-85'	"	"	"	Driven and drilled
T26N-R7E, Sec. 21	15-100'	"	"	"	Driven and drilled
T29N-R6E, Sec. 15	15-65'	"	"	"	Driven and drilled
T27N-R8E, Sec. 18	30-120'	"	"	Gravel and limestone	Driven and drilled

Typical Wells of Wabash County (continued)

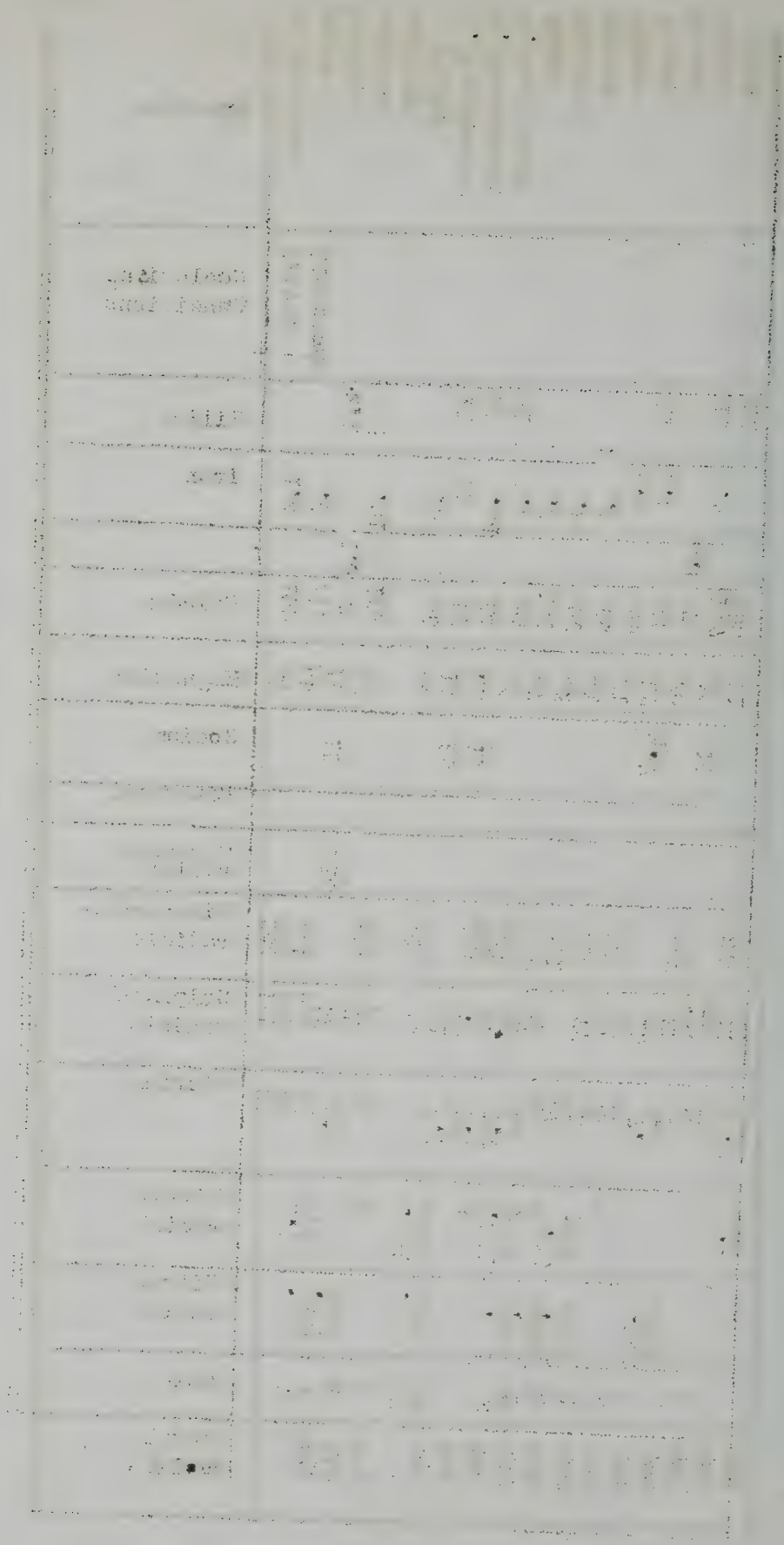
Location	Depth	Quality	Quantity	Formation	Construction
T28N-R7E, Sec. 34	40-100'	Hard	Abundant	Limestone	Driven and drilled
T30N-R7E, Sec. 3	25-100'	"	"	Gravel	Driven and drilled
T27N-R7E, Sec. 25	20-170'	"	"	Gravel and limestone	Drilled and driven
T27N-R7E, Sec. 28	20-185'	"	"	Gravel	Driven and drilled
T27N-R8E, Sec. 20	15-40'	"	"	Gravel and limestone	Drilled and driven
T26N-R6E, Sec. 19	10-70'	"	"	Gravel and limestone	Driven and drilled
T27N-R5E, Sec. 14	20-30'	"	"	Gravel	Driven and drilled
T30N-R6E, Sec. 3	20-125'	"	"	"	Driven and drilled
T29N-R7E, Sec. 15	20-100'	"	"	"	Driven and drilled
T26N-R6E, Sec. 27	10-110'	"	"	Gravel and limestone	Driven and drilled
T28N-R7E, Sec. 19	70-90'	"	"	Gravel	Driven and drilled
T27N-R6E, Sec. 36	30-70'	"	"	"	Driven and drilled
T28N-R7E, Sec. 6	20-120'	"	"	Gravel and limestone	Driven and drilled
T26N-R6E, Sec. 25	15-120'	"	"	Gravel and limestone	Driven and drilled
Wabash				Water from wells in gravel	
North Manchester	25-140'			" " "	" "
Roann	30-85'			" " "	" "
LaFontaine	15-100'			" " "	" "
Laketon	15-65'			" " "	" "
Dora	30-90'			Gravel	
	90-120'			Limestone	
Lagro	40-100'			"	
Liberty Mills	25-100'			Gravel	
Lincolnville	20-60'			"	
	60-170'			Limestone	
Mailtrace	20-185'			Gravel	
New Holland	15-20'			"	
	30-40'			Limestone	
Redbridge	10-60'			Gravel	
	10-70'			Limestone	
Rich Valley	20-30'			Gravel	
Rose Hill	20-100'			"	
Somerset	10-65'			"	
	65-110'			Limestone	
Spiker	70-90'			Gravel	
Treaty	30-70'			"	
Urbana	20-100'			"	
	100-120'			Limestone	
Vernon	15-80'			Gravel	
	80-120'			Limestone	

MINERAL ANALYSES OF WATERS FROM WABASH COUNTY

(Parts per million)

Location	Geological Conditions	Silica	Iron		Calcium	Magnesium	Sodium	Potassium	Carbonate radicle	Bicarbonate radicle	Sulphate radicle	Chlorine	Nitrate radicle	Nitrite radicle	Color	Total Solids
La Fontaine	Gravel		1.4		102	20				244	159	24				
Lagro	Limestone		.4		119	69				359	178	54	1.5	.002	9	2086
Laketon		2.1		1.9	72	19	15		114		92	5.3		.001	4	816
Laketon			.01		162	35				346	70	59	2		2	676
Liberty Mills			.5		86	34				313	19	3	.001	.008	28	356
N. Manchester		11	12		50	14	24				41	6.1				292
N. Manchester		21	.94		64	25	11			312	13	1.5	5			284
N. Manchester		11	.8		94	4				262	49	1.6	.001	.001	32	390
Roann			.4		146	37				345	96	34	8	.001	2	626
Somerset			.8		96	35				341		34	.05	.001	4	462
Urbana			.2		69	41				324	77	3	1		19	460
Urbana			5.3		89	31				284	87	10			4	466
Wabash		11	1.2		83	27	4.7				13	7.3		.001		340
Wabash				3.1	78	30				329	22	5			4	382
Wabash		19	.7		147	42	10				162	19				634
Wabash		22			53	31				278	25	3.8	.4			286

(149) (From Water-Supply Paper No. 254, p. 229)



W A R R E N C O U N T Y

GENERAL FEATURES

Area 368 square miles Population 9,167 (Census of 1930)

Warren County is situated in the western part of the State. Its western boundary is the Illinois-Indiana State line. It is the fourth county south of Lake Michigan. Williamsport is the county seat.

The maximum altitude of Warren County is 750 feet above sea level; the minimum is 485 feet, thus making a total maximum relief of 265 feet. The maximum local relief is 150 feet. The county has been included in the Tipton Till Plain; however, it may be further divided into three distinct physiographic regions: (1) the river flood plain and terraces; (2) an undulating to rolling belt of timbered land; (3) the level to undulating prairie.

Drainage. -- The larger part of Warren County lies within the Wabash River drainage area. The Wabash forms in part the eastern and southern boundary of the county. Little Pine Creek drains the extreme eastern portion of the county and flows into the Wabash. The east-central part of the county is drained by Kickapoo Creek and its tributaries. The central and north-central part is drained by Big Pine Creek and its tributary, Mud Pine Creek. Rock Creek and Redwood Creek drain an area in the south-central part of the county. Possum Run and the North Fork of Spring Creek drain the southwestern part of the county. All of the above named streams are northern branches of the Wabash. The northwestern part of the county is drained by Jordan Creek and its branch, Little Creek. Jordan Creek is a tributary of the Vermillion River, the waters of which reach the Wabash in Vermillion County, to the south.

GEOLOGY

The river flood plain of the Wabash in Warren County ranges from the one-fourth of a mile to 2½ miles in width. The alluvium is variable in thickness, ranging from a few feet to 20 feet. The bottoms are usually bordered by broad low benches or massive gravel terraces that rise from 25 to 75 feet above low water in the river. The "Barrens" southwest of Williamsport, the terrace east of Kickapoo, and "Mound Prairie" on the southern boundary of the county are the best defined terraces. Large springs have issued from many of the terraces.

Warren County is crossed by several conspicuous ridges of drift. The county is within the Wisconsin glacial invasion. It is estimated that fully one-half the area of the county is occupied by morainal drift, The remainder of the county has till at the surface. The drift varies from the outcrops of bedrock where it is entirely gone to thicknesses of 400 feet.

Mississippian and Pennsylvanian strata underlie the county. The northeastern part of the county is underlain by Mississippian (Borden) strata. They outcrop as far westward as Williamsport, occurring some two or three miles down the Wabash below Williamsport

The remainder of the county has Pennsylvanian (Pottsville and Allegheny) rocks underlying the drift. The strata dip west to southwestward.

Generalized Geologic Section for Warren County

Quaternary:	
Recent	0- 75'
Pleistocene	0-400'
Pennsylvanian:	
Allegheny, --	
Pottsville, --	
Mississippian	500'?

GROUND WATER

Sand and gravel occuring either in glacial drift or river deposits are the chief sources of ground water in Warren County. Few deep wells have been drilled in the county. Water in sufficient quantities is obtained at fairly shallow depths, though many water wells go to 200 and 300 feet. Leverett(150) has given information on individual wells as follows.

(150) Leverett, Frank. Wells of Northern Indiana. U. S. Geological Survey, Water-Supply Paper No. 21, 1899, pp. 66-67.

"At Williamsport, the county seat, wells vary greatly in depth there being a range from 14 feet up to about 100 feet. In a portion of the city rock is struck at 10 to 15 feet, but there are places where the drift attains a thickness of 85 feet. A boring f gas at this city, 1,540 feet in depth found fresh water at a depth 65 feet in great quantity; also, at about 165 feet. From the lat depth water rises within 32 feet of the surface. Salt water was struck at about 1200 feet. Gas not being obtained, the salt water was shut off, and the fresh water is thus available for water supp The well is estimated to yield 20 gallons per minute.

On the Wabash terrace below Williamsport, which stands about 1 to 110 feet above the river, several wells have been sunk to the level of low water in the river. They are through gravel or sand their entire depth. The water rises and falls with the rise and fall of the river.

A boring for coal at West Lebanon pentrated a soil containing wood and leaves beneath the blue till at a depth of 140 feet. Roc was entered a short distance beneath this soil. About a mile sout east from West Lebanon, on ground nearly 100 feet higher, rock is struck at a depth of only 60 feet."

The Mississippian strata which underlie the county are not wat bearing. The Pennsylvanian formations contain several strata whic bear fresh water, notably the sandstones and coals. In some insta the Pennsylvanian strata bear mineralized water. With water in su ficient quantities to meet all ordinary needs, at shallow depths, i is not necessary to test out the deeper formations. The shales of the Pennsylvanian will not bear water, and when the Mississippian (Borden) formations are penetrated, it is useless to continue furt drilling in the quest of fresh water.

Water Supplies of Towns in Warren County

West Lebanon. -- (population 595) The town of West Lebanon owns its water system. Two wells furnish the supply. The water level is from 15 to 50 feet in the community.

Williamsport. -- (population 1,053) Williamsport owns its water system. Two wells drilled into sand furnish the supply. Bedrock is penetrated here at 210 feet, and the water level is reported to be 100 feet.

Pence. --(population 173) Pence is supplied water from a tubular well, privately owned.

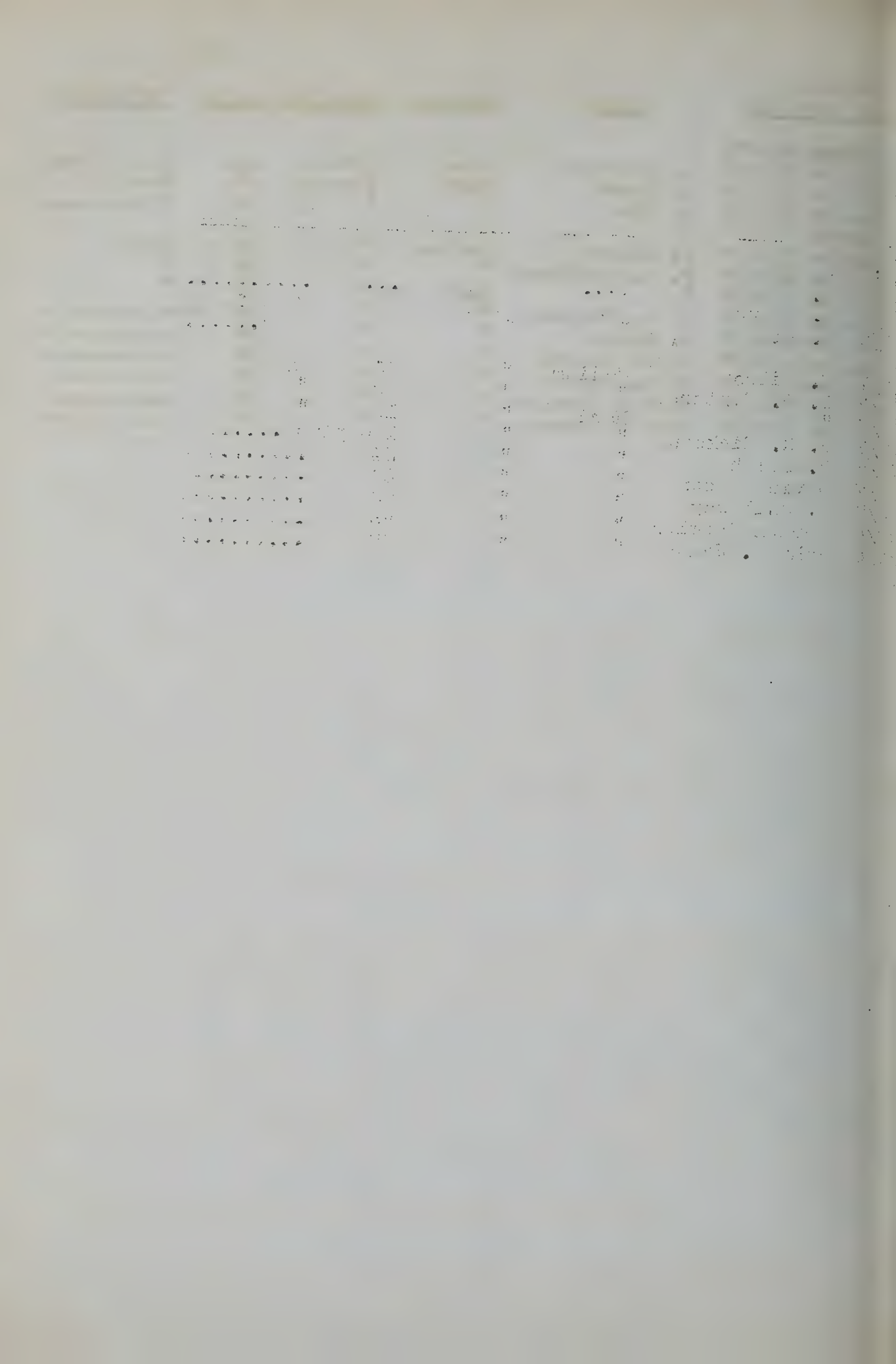
Pine Village (population 323) and State Line City (population 165) do not maintain public water systems.

Typical Wells of Warren County

Township and Section	Well	Quality	Quantity	Depth	Formation
J. Q. Adams					
S.W.¼-11/23/7	Rosa Ritenour	Hard	Plenty	40'	.....
S.W.¼-10/23/7	John Ritenour	"	"	35-72'	Sa.-(Coal)
S.E.¼-9 /23/7	C. B. Russell	"	"	45	.....
S.E.¼-8 /23/7	Wm. Bisel	"	"	135	.....
S.W.¼-8 /23/7	R. P. Strong	"	"	83	.....
Pine Village	.....	.....	.....	18-20	.....
S.E.¼-7 /23/7	Joe Howarth	Hard	Plenty	45-82	Sandstone
N.W.¼-7/23/7	J. Reed	"	"	25	.....
S.W.¼-7 /23/7	Fred Albright	Medium	"	32	.....
Jordan					
S.E.¼-11/22/10	Pence, P.O.	Soft	"	161-60	Stone
N.W.¼-13/22/10	McClaughlin	Medium	"	60	.....
N.W.¼-18/22/9	Miller-Elevator	Hard	"	80	.....
N.E.¼-17/22/9	Wm. Beavers	"	"	40	.....
N.E.¼-16/22/9	Harry Pence	Soft	"	17	Gravel
S.E.¼-10/22/9	J. H. Worley	Hard	"	40	"
N.E.¼-14/22/9	C. Watson	....	"	160	"
Kent					
N.W.¼- 6/20/9	Jay Cryte	Soft	"	300	.....
S.E.¼-16/20/10	Jane Vinson	"	"	...	Cistern
S.W.¼- 7/20/9	Gopher Hill School	Hard	"	200?	.....
S.W.¼- 7/20/9	J. A. Beckett	Medium	Limited	200	.....
N.E.¼-21/20/10	F. Fowler	Salt	"	417	.....
S.W.¼-18/20/9	Homer R. Clem	Hard	Plenty	...	.....
S.W.¼-19/20/9	O. M. Perry	"	Coal Gas & $CaCO_3$	100?	.....
S.W.¼-19/20/9	Joe Gouty	V.Hard	Plenty-Fe	109	.....
N.W.¼-30/20/9	Humphrey Beckert	Hard	Plenty	24	Gravel
S.E.¼-30/20/9	Depot-Foster	"	"	95	"
Liberty					
S.E.¼-11/22/9	C. Watson	"	"	...	.....
S.W.¼-12/22/9	O. R. Judy	"	.....	120	.....
S.W.¼- 7/22/8	Clark Dick	Mineral	Plenty	270	.....
N.E.¼-17/22/8	Joe Green	Hard	"	18	.....
S.W.¼- 8/22/8	Auto Hutz	"	"	40	Rock
N.E.¼-16/22/8	J. W. Booth	Medium	"	83½	.....

Township and Section	Well	Quality	Quantity	Depth	Formation
N.E.¼-15/22/8	Andy Myers	Hard	Plenty	36	Clay
S.E.¼-11/22/8	J. Klein	Hard-Fe	"	107	.....
S.W.¼-12/22/8	Frank Anderson	Hard	"	40	.....
Medina					
S.E.¼-16/23/6	C. A. Johnson	"	"	35'	.....
S.W.¼- 8/23/6	H. J. Waddell	"	"	...	.....
S.W.¼ 8/23/6	C. Corbett	"	"	...	.....
S.W.¼- 7/23/6	Wm. Ice	"	Limited	45	.....
S.E.¼-12/23/7	L.J.Wettscharock	"	Plenty	...	.....
S.W.¼- 7/23/6	S. E. Morgan	"	"	35	Sand
S.W.¼-12/23/7	Wm. Clay	"	"	40	.....
Pike					
N.W.¼-11/T.21/R.8	C. C. Etinre	"	"	111	.....
N.W.¼-11/21/8	"	"	Limited	32	Sandstone
S.W.¼-11/21/8	Clarence Rise	....	Plenty	60	Sand
S.W.¼-10/21/8	L.Shannon	Medium	"	165	"
S.W.¼- 9/21/8	O.W.Fullenlove	Hard	"	40	Gravel
N.W.¼- 8/21/8	B. Johnson	"	"	35	.....
S.E.¼- 7/21/8	H. Mansen	....	.....	60	.....
S.W.¼- 7/21/8	"	See Note #1 Hard	Plenty	288	Coal
S.W.¼- 7/21/8	C. L. French	Hard	"	63	Gravel
N.E.¼-12/21/9	L.Chandler	Soft-Fe	"	95	.....
S.E.¼-12/21/9	C. Ford	Hard	Limited	...	.....
S.E.¼-12/21/9	"	....	Flowing	...	.....
Pine					
S.W.¼-12/23/8	C. Everbe	Hard	Plenty	40	.....
S.E.¼-10/23/8	Thos. Young	"	"	28-74½	Gravel
S.W.¼-11/23/8	John Graves	"	"	...	"
S.W.¼-10/23/8	A. M. Tribblit	"	"	...	"
N.W.¼-15/23/8	John Grames	"	"	85	"
S.E.¼-16/23/8	N.S. St. John	Medium	"	50	"
N.W.¼-16/23/8	C. E. Lamb	Hard	"	50	"
S.E.¼-18/23/8	R. Lamb	"	Limited	35	"
Prairie					
S.E.¼- 18/23/9	Jas. Bowman	"	Plenty	38	.....
S.W.¼- 18/23/9	John W Little	"	"	40	Gravel
S.E.¼-13/23/10	Chas. Hartlip	Condemned	"	47	.....
S.W.¼-14/23/10	E. Meharry	Hard	"	45	.....
S.E.¼-13/23/9	Roy Borders	"	"	64	.....
S.W.¼-14/23/9	J. Fraley	"	"	85	.....
S.E.¼-15/23/9	J.H. High	Fe. S.	"	85	Gravel
S.E.¼-16/23/9	A. R. Graves	Hard	Limited	47	Sand and Gravel
S.E.¼-17/23/9	George Tatlock	"	Plenty	20	" "
Steuben					
N.W.¼-12/21/10	Frank Clark	"	"	120	Gravel?
N.E.¼-12/21/10	"	Soft	"	90	Sandstone
N.E.¼-11/21/10	A. Andrews	Hard	"	40	.....
N.W.¼-18/21/9	F. Whorley	"	"	...	Sand
S.E.¼-24/21/10	Chas. Alburn	"	"	183	"
N.W.¼-31/21/9	W. W. Irving	Hard	Plenty	80'	Gravel
N.W.¼-31/21/9	Elevator	Soft	"	60	"
N.E.¼-31/21/9	W. W. Irving	...	....	300	.....
N.E.¼-10/21/9	G. Astell	Hard	Plenty	40	.....
N.W.¼-10/21/9	J. Day	"	.....	38	.....
S.W.¼- 9/21/9	F. Goodwine	"	Plenty	...	.....

Township and Section	Well	Quality	Quantity	Depth	Formation
Steuben cont'd					
S.E.¼- 8/21/9	F. Goodwine	....	Spring	...	.....
S.W.¼- 8/21/9	W. Clark	Hard	Plenty	60	Sand ?
S.W.¼- 7/21/9	H. Blue	"	"	100	plus.....
Warren					
N.E.¼- 7/22/7	F. Wilson	Medium	"	60	Sand
N.E.¼- 8/22/7	P. O. Winthrop	"	"	60	"
N.E.¼- 8/22/7	"	Hard	"	19	"
N.W.¼- 9/22/7	J. R. Hickman	"	"	100 plus	.....
S.E.¼-10/22/7	H. Smith	"	"	34	.....
N.E.¼-11/22/7	David Benson	"	"	86	.....
S.W.¼-12/22/7	G. Galloway	"	"	90	.....
S.E.¼- 7/22/6	Merton Knowles	"	"	85	.....
S.W.¼- 9/22/6	John W. James	"	"	87	.....



W A R R I C K C O U N T Y

GENERAL FEATURES

Area 368 square miles Population 18,230 (Census of 1930)

Warrick County is located in the southwestern part of the State. Its southern boundary is the Ohio River, and it is the third county east of the Illinois-Indiana State line. Boonville is the county seat.

The maximum elevation in the county is 660 feet above sea level the minimum is 330 feet, thus making a total maximum relief of 330 feet. The maximum local relief is 260 feet. The county is a part of the Wabash Lowland. With the exception of some lacustrine deposits in the northwestern corner of the county, the entire area is within the unglaciated part of the State. The topography is the result of weathering and erosion on Pennsylvanian shales. The resistant sandstone strata have stood up to form ridges; The non-resistant shales have been eroded away. The aggraded valleys are characteristic of the county. The proximity of the Ohio toward which the streams are cutting as a base is responsible for the considerable relief.

Drainage. --Warrick County lies largely within the Ohio River drainage area. A small part of the surface water from the northern part of the county passes into the Patoka River, from that stream into the Wabash, and thence to the Ohio. Little Pigeon River forms the boundary line for a large part of the eastern portion of the county and its tributaries are responsible for the gathering of the surface waters in that section. These tributaries from east to west are Wallace Creek, Polk Patch Creek, Cooks Branch, Brush Fork, Barren Fork, Otter Creek, and Cypress Creek. Big Pigeon Creek drains the western part of the county. Its principal eastern tributary is Squaw Creek.

GEOLOGY

The residual soils and valley flats of the Ohio, Little Pigeon River, and other streams are the main unconsolidated deposits of the county. Lacustrine deposits associated with the ponding caused by glaciation occur in the northwestern corner of the county, but the latter occur in an area not exceeding 10 square miles.

The strata underlying the county are of Pennsylvanian age. All three main divisions of the Pennsylvanian recognized in Indiana are present in outcrops. The strata dip westward. Pottsville, Allegheny, and post-Allegheny, rock outcrop from east to west across the county. The exposures of Pottsville are limited to the eastern edge of the county.

Generalized Geologic Section for Warrick County

Quaternary:	
Recent, -- chiefly alluvium	0- 20'
Pleistocene, -- River terrace	0- 50'
Pennsylvanian	1000'

Post-Allegheny, --
Allegheny, --
Pottsville, --

GROUND WATER

Surface water. -- Surface water supplies in Warrick County may be obtained from springs and streams. Surface waters have been collected by the building of reservoirs in many parts of the count At one time Boonville had an artificial lake which supplied the city with water.

Ground water. -- Ground water may be obtained from the terrace deposits along the Ohio, from the valley flat of the Ohio, or othe streams, or from bedrock. Locally beds of gravel along stream courses are important as sources of water.

In many areas the water supply is obtained from shallow wells which penetrate the Pennsylvanian strata. The logs of wells drill for oil and gas show the presence of many water sands down through the Pennsylvanian. Several coal strata bear potable waters. The shales of the Pennsylvanian are relatively impervious, though serv to impound water so that it cannot escape downward or upward.

It is likely that any stratum deeper than the Pennsylvanian would not bear potable water: hence deep drilling for ground water cannot be encouraged.

Water Supplies of Towns in Warrick County

Boonville.-- (population 4,208) Boonville owns its water supply. Five wells obtain water from alluvium. Bedrock was not encountered. Three of the wells are 10" wells, two are 16" in dia meter. It is 14' to the water level.

Newburg. -- (population 1,262) Newburg is supplied water from one tubular well, privately owned. Bedrock is penetrated at 78 fe the water level is 38 feet.

Elberfeld (population 546); Lynnville (population 264); and Tennyson (population 335) are other towns in Warrick County. They do not maintain public water supplies.

WASHINGTON COUNTY.

GENERAL FEATURES

Area 519 square miles. Population 16,285 (Census of 1930)

Washington County is situated in central southern Indiana. It is the second county north from the Indiana-Kentucky State line. It is the fifth county east of the Indiana-Illinois State Line. Salem is the county seat.

The maximum elevation in the county is 1,015 feet above sea level; the minimum is 495 feet, thus making a total maximum relief of 520 feet. The maximum local relief is 400 feet. The southwestern one-half of the county is included in the Mitchell Plain; the northeastern one-half is a part of the Norman Upland. That part of the county within the Mitchell Plain is generally level. The remainder of the county with the exception of the Muscatatuck and White River bottoms is very rugged. In the Norman Upland area occur a series of deep, narrow valleys, from 150 to 300 feet deep, from 1 to 5 miles long and separated by flat-topped, narrow divides. These divides are broken which gives rise to the Knob-like topography.

Drainage.-- The drainage of the northern part of Washington County is a part of the White River system. That of the southern part of the county is a part of the Blue River system and is conveyed by it directly to the Ohio. The drainage of the northern portion reaches the Ohio by a long circuitous route. Much of the drainage of the western part of the county is subterranean.

The East Fork of White River forms the boundary for the northwestern part of the county. The remainder of the northern boundary is formed by the Muscatatuck River. Rush Creek and Buffalo Creek are tributaries of White which aid in the drainage of the north part of the county.

Delaneys Creek and Elk Creek are southern branches of the Muscatatuck, in the northern part of the county. Henry Creek is a small branch of the Graham Fork of the Muscatatuck. It is located in the northeastern part of the county.

Blue River with its eastern branches, Mutton Fork and Middle Fork and Mill Creek, and Honey Creek drain a large area in the southern part of the county. Lost River drains a small area in the western part of the county.

GEOLOGY

Alluvium occurs along the bottoms of the Muscatatuck and White Rivers and along the meander curves of Blue River. The northeastern quarter of the county is glaciated, though the deposits are thin on the uplands. The rough topography with deep valleys accounts for many springs, and the inability to secure water on the ridges.

The Mississipian system of rocks is represented in the county. The Border Harrodsburg, Salem, St, Louis, Ste. Genevieve and Chester

formations are represented in the county.

Generalized Geologic Section for Washington County

Quaternary:	
Recent	0- 20'
Pleistocene	0- 20'
Tertiary:-- Cherty conglomerate and sand	0- 80'
Mississippian:	
Chester	0- 75'
Ste. Genevieve	100' ±
St. Louis	175' ±
Salem	40-60'
Harrodsburg	60-75'
Borden, -- Calculated	605'
Rockford, -- (No outcrops).	
Devonian: (Not exposed)	

GROUND WATER

Natural springs are abundant in Washington County. Several notable spring horizons are present. They are at the contact of the Borden and Harrodsburg, Salem and Harrodsburg, 50 feet above base of St. Louis and also above the Salem formation. The limestone belt presents some problems of water supply. Subterranean drainage is well developed and in many areas uncontaminated water is difficult to obtain. The Borden formations are not aquifers. Usually good supplies of water are available from the valley flats along the major streams and in alluvium-filled valleys. The Chester formations occur in part in the southwestern corner of the county and are relatively unimportant as a source of water in this county. Wells that penetrated the limestones of the St. Louis, Ste. Genevieve, Harrodsburg, or Salem can usually obtain supplies. Joint cracks, bedding planes, and underground fissures contain water in these formations. Frequently underground drainage permits the waters to be drained away. Usually there is excellent chance for surface pollution in the limestone areas.

Water Supplies of Towns in Washington County

Salem. -- (population 3,194) Salem owns its water supply, which is obtained from natural springs.

These towns in Washington County maintain no public water system: Campbellsburg (population 558) ; Saltillo (population 160); Little York (population 140); Livonia (population 168); New Pekin (population 383); Fredericksburg (population 216); and Hardinsburg (population 254).

WAYNE COUNTY

GENERAL FEATURES

Area 411 square miles Population 54,809 (Census of 1930)

Wayne County is located in eastern Indiana. Its eastern boundary is the Indiana-Ohio State line. It is the fourth county north of the point where the Ohio River first touches Indiana. Richmond is the county seat.

The maximum elevation in Wayne County is 1,250 feet above sea level; the minimum is 820 feet, thus giving a total maximum relief of 430 feet. The maximum local relief is 150 feet. The broad valleys of the various Forks of the White-water River and the extensive outwash plains with the heavy accumulations of drift in the northern and western portions of the county are the prominent features.

Drainage.— The surface waters of Wayne County flow into the Whitewater and then to the Ohio. The West Fork of Whitewater River flows through the western part of the county, in a southerly direction. Nettle Creek is its principal tributary from the northwest and Martindale Creek from the northeast, Greens Fork, another tributary, drains the northcentral part of the county, Nolands Creek drains the northeastern and south-central parts of the county. Its eastern tributary is Butler Creek in the southern part of the county. The East Fork of Whitewater River flows southward in the southeast part of the county and receives the waters from East Creek, West Creek, and Elkhorn Creek.

GEOLOGY

The valleys of the various streams which flow from north to south across the county cut wide valleys during the melting of the glacial ice. The valleys are wider than the present stream channels, and in many instances were filled with drift. Later a thin mantle of drift was spread over the entire area. These old valleys and gravel plains in the western part of the county are excellent sources of ground water. The gravel plains are outwash deposits and valley train materials. On the uplands between the gravel plains the drift consists of till, and wells are obtained from 30 to 50 feet.

Well records show that the rock surface of the county is very irregular. A gas-boring at Dalton in the northeast corner of the county logged 275 feet of drift. At Walnut Center in the western part the drift is 280 feet. At Washington, near the center of the county, it is 212 feet. South of Richmond the till ranges from 50 to 60 feet in thickness.

The bedrock strata of Wayne County are of Ordovician and Silurian age.

Generalized Geologic Section for Wayne County

Quaternary:	
Recent	0- 20'
Pleistocene	0-300'

Silurian: . . . . . ?
Ordovician: . . . . . ?

GROUND WATER

The gravels of the outwash plains and drift are the chief source of water supply in Wayne County. A few deeper wells penetrate limestone, but most of the private supplies are obtained from alluvium or gravels associated with the drift. Leverett (151) has given the following information about individual wells in Wayne County:

(151) Leverett, Frank, Wells of Southern Indiana. U. S. Geological Survey, Water-Supply Paper No. 26, 1899, pp. 32-3

"At Hagerstown, in the northwest part of the county, flowing wells are obtained in the valley of Nettle Creek at a depth of about 80 feet. They are largely through gravel, but penetrate a bed of till just above the water vein. In eight gas borings made in the vicinity of Hagerstown, along the valley of Nettle Creek, the drift has an average depth of about 100 feet. The least distance to rock is 78 feet.

"At Williamsburg, in Greens Fork Valley, in the north part of the county, wells are obtained at 18 to 25 feet, mainly in gravel. At Fountain City, in the valley of Nolands Fork, wells are obtained at similar depth. A gas boring at Fountain City penetrates 185 fee of drift.

"At Richmond wells are obtained at from 12 to 40 feet. In a few instances water is obtained in the drift, but usually the wells enter the limestone. ----

"At Centerville, near the valley of Nolands Creek, a gas-well boring penetrates 176 feet of drift, mainly till. Ordinary wells are obtained at 30 or 40 feet, more or less. Another gas boring is reported by Dr. Phinney to have about 250 feet of drift, with a flow of water at 246 feet.

"At Cambridge City, in the valley of West Whitewater River, wells are usually obtained in gravel at 15 to 25 feet. Two gas-well borings at this city enter rock at about 100 feet. After passing through 15 or 20 feet of gravel, the drift is mainly blue till.

"On the uplands east of the West Whitewater, in the southern part of the county, water wells in some cases reach a depth of 80 feet without striking rock. On the uplands west of this stream, gas-well borings have shown the drift to have a thickness of 150 to 300 feet, the greatest thickness noted being found in the village of the vicinity of Cambridge City, showing that the rock surface has a variation of fully 200 feet within 1 or 2 miles of that city.

"On the plain south of Richmond, in the southeast corner of the county, wells have, in some instances, been sunk to a depth of 60 feet through till without entering rock. As a rule, however, rock is found in that part of the county at 50 feet or less, and

over quite extensive area it has outcrops nearly as high as the bordering upland."

The limestones which underlie the glacial deposits usually contain ground water which is available. The Silurian strata which underlie the drift in the northern third of the county and along the eastern margin are usually good aquifers. The Ordovician rocks which outcrop at various points and which underlie most of the southern two-thirds of the county are more shaly, The limestone horizons of the Ordovician are water-bearing when next to the drift.

The abundance of gravels as outwash plains, valley trains, and drift assure the county a plentiful water supply, so it is unnecessary to do deep drilling. In the county strata lower than the very upper bedrock are likely to bear mineralized waters, unfit for use.

Water Supplies of Towns in Wayne County

Centerville. -- (population 993) Centerville owns its water system. Two wells which penetrate a gravel bed furnish the supply. The water level is 35 feet below the surface.

Cambridge City. -- (population 2,113) Cambridge City owns its water works. Two wells which penetrate gravel at about 50 feet furnish the supply.

Hagerstown. --(population 1262) Hagerstown owns its water works. Two wells furnish the supply from gravel. The water level is near the surface. Springs are numerous in this locality.

Milton. -- (population 612) Milton owns its water system. Two dug wells furnish the supply. The water level is within 20 feet of the surface.

Richmond. -- (population 32,493) The Richmond Water Works Corp. furnishes the city of Richmond with water from wells, infiltration galleries, and natural springs. Five wells are in use at the present time. The water comes from the alluvium over the bedrock. Bedrock occurs at 20 to 25 feet.

The following incorporated towns in Wayne County do not maintain public water systems: Boston (population 184); Greensfork (population 333); Whitewater (population 121); Dublin (population 727); East Germantown (population 291); Mount Auburn (population 161); Fountain City (population 480);Economy (population 212); and Spring Grove (population 191).

Typical Wells of Wayne County

Location	Depth	Quality	Quantity	Formation	Construction
T15N-R1W					
Sec. 20	20'	Hard	Good	Gravel	Dug
T14N-R1W					
Sec. 9	26-80	"	"	"	Drilled & Dug (Chester)
Sec. 31	18-20	"	"	"	Dug
T17N-R14E					
Sec. 21	20-30	"	"	"	Driven
Sec. 21	12	"	"	"	" (Webster)

Location	Depth	Quality	Quantity	Formation	Construction
T17N-R13E					
Sec. 24	40-50	Hard	Good	Gravel	Drilled
Sec. 27	22-30	"	"	"	Driven
T17N-R12E					
Sec. 21	50	"	"	"	Drilled
Sec. 24	65-85	"	"	"	Driven (Hagerstown)
T16N-R12E					
Sec. 25	35	"	"	"	Drilled
Sec. 27	70	"	"	Limestone	" (Cambridge Cl
Sec. 29	28-125	"	"	" and Gravel	Drilled (Dublin)
T15N-R13E					
Sec. 23	18-20	"	"	Gravel	Driven
Sec. 30	30	"	"	"	"(Pennville)

WELLS COUNTY

GENERAL FEATURES

Area 365 square miles Population 18,411(Census of 1930)

Wells County is located in the northeastern part of Indiana. It is the second county west of the Indiana-Ohio State line and the fourth county south of the Indiana-Michigan line. Bluffton is the county seat.

The maximum elevation in the county is 900 feet above sea level, the minimum is 750 feet, thus making a total maximum relief of 150 feet. The maximum local relief is 75 feet. The greater part of the surface is an uneven plain. Throughout the northeastern, west central, and south central parts of the county the topography varies from nearly level to gently undulating. The Wabash River crosses the middle of the county in a northwesterly direction, and the Salamonie River has a similar course in the southwestern part. Their valleys are narrow and comparatively shallow. Much of the minor drainage of the county flows from southwest to northeast. Three moraines cross the county, trending northwest-southeast. The central moraine, near Poneto is a remnant of the Salamonie Moraine. See Plate III of this report.

Drainage. -- The drainage of Wells County is divided between the Wabash River and the Salamonie River basins. The Wabash enters the county about eight miles north of the southeastern corner and trends in a northwesterly direction to leave the county about seven miles south of the northwestern corner.

The northeastern portion of the county is drained by a small branch of St. Marys River. The northwestern part by Flat Creek and Eight Mile Creek, both of which are tributaries of the Little Wabash. Rock Creek, a southern tributary of the Wabash, drains an area in the western and southern parts of the county. The Salamonie River and its tributaries, the principal one of which is Prairie Creek, drain the southwestern part of the county.

The southeastern portion of the county is drained by Mill Creek a branch of Beavers Creek and of the Salamonie; and by Haskins Run, a tributary of the Wabash River.

GEOLOGY

The drift of Wells County is a rather uniform compact till at the surface, with thin beds of sand included in or underlying it. The average thickness of the drift, unless present in concealed valleys, does not exceed 50 feet.

The streams of the county are flowing in small, shallow valleys, cut but 20 to 40 feet into the plains. The alluvium is not thick and is relatively unimportant as a source of water supply.

The bedrock which underlie Wells County are of Silurian age. The eastern half of the county is probably underlain by Huntington dolomite, the western half by Liston Creek Limestone. The latter is quarried at a few points in the county, namely near Bluffton and at Rockford.

Generalized Geologic Section for Wells County

Quaternary:
Recent, ... 0- 10'
Pleistocene, ... 0-100'
Silurian:
Huntington, - dolomite . . . . . (Thickness undetermined)
Liston Creek, limestone . . . Exposed in quarried 15-30 feet.

GROUND WATER

The chief sources of ground water in Wells County are the drift and the underlying limestone. An inventory of the wells of the county shows that limestone is the chief aquifer. Along the Wabash River there are numerous outcrops of rock, but wells usually obtain water above the rock. On the Salamonie Moraine the wells range in depth from 20 to 75 feet through till. Along the Wabash moraine in the north part of the county penetrated 50 to 75 feet of till. A well at Kingsland was reported to penetrate bedrock at 80 feet, mainly through till. Unless gravel and sand is found in the till deposits, the wells are only seep wells and do not furnish abundant supplies. Where gravel and sand are penetrated adequate supplies are obtained.

The Silurian limestones which underlie the glacial drift are aquifers and wells which penetrate these bedrock formations usually obtain good water in sufficient quantities.

Water Supplies of Towns in Wells County

Bluffton. -- (population 5,074) Bluffton owns its water works system. Eight tubular wells penetrated the underlying limestone for the supply. Bedrock is reported at 300 feet. The water levels are reported to go down during the dry season.

Ossian, --(population 788) Ossian owns its water system. The supply is obtained from a tubular well.

Markle, -- (population 621) Markle owns its water supply. Th water is obtained from one tubular well.

The following towns in Wells County do not maintain public wate supply systems: Poneto (population 237); Vera Cruz (population 94); Uniondale (population 226).

WHITE COUNTY

GENERAL FEATURES

Area 507 square miles Population 15,831 (Census of 1930)

White County is located in northwestern Indiana, the second county east of Illinois, and the third county south of Lake Michigan.

The maximum altitude of White County is 760 feet above sea level which is the average for the state of Indiana. The lowest elevation is 540 feet above sea level, thus giving a maximum relief of 220 feet. The maximum local relief is 110 feet.

The northern half of White County is a portion of the Kankakee Lacustrine plain, characterized by black, formerly marshy, sandy lands and light sand ridges. The southern half of the county is a glacial plain with low moraines and areas of till plain.

This county lies mainly within the Tippecanoe River drainage basin. The Tippecanoe River flows through the eastern part of the county from north to south and enters the Wabash about three miles south of the southeast corner of White County. Indian Creek, Little Indian Creek, Kean's Creek, and Pike Creek are branches of the Tippecanoe, which drain the northeastern part of the county. The northwestern part of the county is drained by Monon Creek, its principal branch, Little Monon, and by Honey Creek. These are western branches of the Tippecanoe. The southwestern part of the county is drained by Big Creek, Spring Creek, and Moot's Creek, all of which are western branches of the Tippecanoe River.

GEOLOGY

The unconsolidated surface deposits of White County consist of glacial drift and deposits made in marsh and lake areas. The sands, muck, and clay in the area of the Kankakee Lacustrine deposits of the northern half of White County are usually underlain by deposits of glacial till and gravels. The south half of the county has morainal deposits and till plain area at the surface. Both areas contain ground water in the unconsolidated deposits.

The glacial deposits of White County are underlain by bedrock of Silurian, Devonian, and Mississippian age.

Bulletin #75, Dept. of Conservation, p. 178, describes a quarry in White County as follows:

"Stone is being quarried at only one locality in White County. About one mile south of Monon, in the center of Sec. 28, T. 28 N., R. 4 W., an active quarry is being operated on the east side of the road. The quarry is in a reef in the Huntington dolomite (Silurian). The stone is crushed and much of it is shipped to distant points for road material. Considerable petroleum gives the rock a brown or black color. Under prolonged weathering, however, the color changes to gray or white. The quarry opening is about 55 feet deep. An abandoned quarry, now partly filled with water, lies

across the road from the active quarry. The stone is similar to that being quarried at the present time."

The Silurian rocks underlie the northeast quarter of the county roughly covering that portion of the county northeast of a line extending two miles southwest of Idaville to a point two miles southwest of Monon.

The southwestern quarter of White County is underlain by rocks of Mississippian age. The remainder of the county , the central portion, is underlain by rocks of Devonian age.

Near the town of Wolcott occurs an outlier of sandstone of Pennsylvanian age.

Generalized Geologic Section for White County

Quaternary:
Recent sands, -- clays and gravels . . . . . 0- 40'
Pleistocene sands, -- clays and gravels . . 0-250'
Pennsylvanian: sandstones . . . . . 0- 40'
Mississippian: siltstone and shales
(Thickness unknown)

Sources of Water Supply

Surface water supplies in White County may be obtained from springs, ponds and streams. The necessity for impounding surface waters does not exist because of the abundance of water in the glacial covering. Ponds for collecting of stock water exist in certain parts of the county.

Ground water supplies may be obtained from a number of formatic Ground waters may be obtained from the Recent sands and gravels, Pleistocene sands and gravels, Pennsylvanian sandstones, Mississippian limestones, Devonian limestones, Silurian limestones and Ordovician limestones. The waters obtained from the upper fou horizons are generally potable. Those obtained from the lower bedrock formations are generally mineralized.

Water Supplies of Towns in White County

Brookston. -- (population 844) Brookston obtains a supply of water from one well which produces from the coarse gravels at approximately 75 feet in depth. The well is cased with 10 inch casing. The town owns the supply.

Chalmers. -- (population 510) The town of Chalmers has no public water supply.

Burnettsville. -- (population 402) The town of Burnettsville has no public water supply.

Monticello. --(population 2,331) Monticello obtains water fro wells at approximately 80 feet to water level. The wells are eig inches in diameter and are reported to yield good water. Glacial drift is reported to be 250 feet in thickness. The city owns the supply.

Monon. -- (population 1,374) The town of Monon obtains a supply of water from two wells producing from the blue limestone. Bedrock occurs near the surface at Monon and several artesian wells are found in and near the town. The water is hard and contains some sulphur which comes from the iron pyrites contained in the limestone. The town owns the supply.

Reynolds. -- (population 362) The town of Reynolds has no Public water system.

Wolcott. -- (population 747) Wolcott owns an impounding reservoir, from which water is obtained.

Typical Wells of White County

Location	Depth	Quality	Quantity	Formation	Construction
T26N-R3W					
Sec. 12	20-25'	Hard	Good	Sand & Gravel	Driven
Sec. 15	20-70	"	"	" "	Drilled
T28N-R4W					
Sec. 13	15-20	"	"	" "	Driven
Sec. 21	282-287	"	"	Limestone	Drilled
T27N-R4W					
Sec. 5	80'	"	"	"	"
Sec. 28	50-250	"	"	Gravel	"
T25N-R4W					
Sec. 22	157'	"	"	Limestone	"
Sec. 24	12-20	"	"	Gravel	Driven
T26N-R4W					
Sec. 34	30	"	"	"	"
T27N-R6W					
Sec. 22	65-100	"	"	"	Drilled
Sec. 22	100	"	"	Limestone	"
Sec. 25	(3)190	"	"	Sandstone	"
Sec. 25	160	--3 feet water bearing sand			
Sec. 6	85	Hard	Good	Gravel	"
Sec. 6	100	"	"	Rock	"
Sec. 7	87	"	"	Limestone	"
T27N-R8W					
Sec. 25	22	Soft	"	Gravel	Driven
Sec. 28	10-100	"	"	"	Drilled & driven
Sec. 21	---	"	"	"	Flowing wells
T27N-R3W					
Sec. 25	127	Hard	"	Limestone	8' in lime-Stone
Sec. 11	40	Soft	"	Gravel	
Sec. 26	40	"	"	"	
Sec. 26	50	"	"	"	
Sec. 26	50	"	"	"	
Sec. 22	60	"	"	"	
Sec. 13	50-60	Hard	"	Limestone	

WHITLEY COUNTY

GENERAL FEATURES

Area 338 square miles Population 15,931(Census of 1930)

Whitley County is located in northeastern Indiana. It is the third county south of the Indiana-Michigan State line and the second county west of the Indiana-Ohio State line. Columbia City is the county seat.

The maximum altitude of the county is 960 feet above sea level, the minimum is 775 feet, thus making a total maximum relief of 185 feet. The maximum local relief is 80 feet. The general surface is rolling and uneven, diversified by a few marked irregularities and limited areas of level land. The surface is the result of weathering and erosion on Wisconsin drift. The northwestern corner of the county, a considerable belt in the center of the county trending northeast-southwest and a similar belt parallel to the latter but a few miles to the southeast are moraines. The intermorainal belts are made up of valley flats and till plain. There are many lakes in the northern part of the county.

Drainage. -- Whitley County lies largely within the Eel River drainage basin. A tributary of the Tippecanoe rises in Cedar Lake. It drains a small area in the northwestern part of the county. Blue River enters the county about two and one-half miles from the northeastern corner and flows southwesterly to enter Eel River near the central part of the county. Clear Creek and Spring Creek are two northern branches of Eel draining an area in the western par of the county. Mud Creek and Stony are tributaries of Eel River which drain areas in the eastern part of the county, Sugar Creek and Hurricane Creek are branches of the Eel draining areas in the southwesterm part. Big Indian Creek, a tributary of the Little Wabash, drains an area in the southeastern part of the county.

Geology

Only a few wells in Whitley County have gone through the entire thickness of the glacial drift. At Columbia City a gas boring had 224 feet of drift. At Larwill a gas boring logged 365 feet of drift. Whitley County has been described as preeminently a clay county, there being but limited areas in which sand or gravel is found at the surface or at slight depth. Over most of the county the clayey drift prevails to depths of 50 or 60 feet and wells which penetrate the till are never large. A narrow belt along Eel River, about a mile in width, has gravel and sand at the surface and strong wells are obtained in these deposits. Many wells find lenses of gravel in the till. Two wells in the county were reported to have penetrated limestone. One well located in Section 35, T. 31 N., R. 10 E and the other located in Section 28, T. 30 N., Range 9 East. The first well penetrated limestone at 285 feet, the other reported limestone at 100 feet. These logs and depths were given from memory and are subject to those limits; however, striking limestone is something extra-ordinary in this county, so perhaps bedrock was penetrated, omitting any question of the

accuracy of the figures.

The wells drilled deep into the drift usually penetrate a sand or gravel horizon. When seep wells are inadequate, they are usually carried to greater depths.

The southern one-third of the county is believed to be underlain by Silurian limestones. The remainder is probably underlain by Devonian strata. The Silurian limestones and the Devonian limestone which lie below the drift immediately to the north of the belt of Silurian rocks are water-bearing. The Devonian shale which is believed to underlie the northern part of the county is relatively impervious and ground water cannot be expected. Strata deeper than the Devonian are likely to contain mineralized water.

Generalized Geologic Section for Whitley County

Quaternary:	
Recent, ...	0- 20'
Pleistocene	50-400'
Devonian: (Not exposed, total thickness unknown)	
Silurian: (Not exposed, total thickness unknown)	

GROUND WATER

The glacial drift is the chief source of water in Whitley County. Wells obtain water from the clayey till, from lenses of gravel, or sand, and a few report water from limestone. Wells located in the Eel River valley reach the bottom of the clayey till at 30 to 40 feet and usually obtain good supplies at greater depths in gravel or sand.

The depth to water-bearing sands and gravels varies considerably. The presence of many lakes in the northern part of the county indicates that the water table is near the surface in that section.

Only a very few instances are known in the county where water is obtained from bedrock. Where the bedrock is limestone excellent water supplies are available. Where the New Albany shale of the Devonian is believed to underlie the drift, no water would be obtained in the shale, but deeper wells should penetrate the limestones and dolomites of the Devonian and Silurian which ordinarily carry fresh water. Northern Whitley County is not far from the outcrop of the Devonian and Silurian limestones, or at least not far from their actual contact with the drift which furnishes the water.

Water Supplies of Towns in Whitley County

South Whitley . -- (population 1,102) South Whitley owns its water system. The source of the water is tubular wells.

Columbia City. -- (population 3,805) Columbia City owns its water works. Six wells supply the city with water. Bedrock is reported at 224 feet. The water level is at 14 feet.

Churubusco. -- (population 1,095) The public water supply at Churubusco is privately owned. Three wells furnish the water. Bedrock is reported at 346 feet.

Larwill -- (population 262) The town of Larwill has no public water supply.

Typical Wells of Whitley County

Location	Depth	Quality	Quantity	Formation	Construction
T32N-R8E	100'	Hard	Good	Gravel	Drilled
T32N-R8E Sec. 27 NW¼	140-150'	"	"	"	"
Sec. 27 NW¼	60'	"	"	"	"
Sec. 28	140-150'	"	"	"	"
Sec. 9 NE¼	25'	Soft	"	"	Dug-15' at barn
Sec. 9	230'	"	---	"	Drilled-no water
Sec. 3 SW¼	20'	"	Fair	"	Driven
Sec. 4 SE¼	20'	"	"	"	"
Sec. 13 NW¼	100'	"	Good	"	Drilled
Sec. 13 SW¼	35'	"	"	"	"
Sec. 18 NE¼	25'	"	"	"	"
Sec. 18 NE¼	170'	Hard	"	"	
T32N-R9E Sec. 9 SW¼	49'	Soft	"	"	
Sec. 9 SW¼	90'	"	"	"	Spring
Sec. 17 SE¼	15'	"	"	Sand	
Sec. 4	105'	"	"	Gravel	
T31N-R9E Sec. 22 NW¼	150'	Hard	Good	Gravel	Drilled
Sec. 29 NW¼	30'	Medium	"	"	Driven
T30N-R9E Sec. 2 SW¼	35-40'	Hard	"	"	"
Sec. 11 NW¼	60'	"	"	"	"
Sec. 24 NE¼	80'	"	"	"	Drilled
T30N-R10E Sec. 16 NW¼	112'	"	"	"	Driven
T31N-R10E Sec. 22	130'	"	"	"	"
Sec. 33 SE¼	65'	"	"	Sand	Drilled
Sec. 35	285'	"	"	Limestone	"
T32N-R10E Sec. 7	91'	"	"	Gravel	Driven
Sec. 9	42'	"	"	"	"

Location	Depth	Qualtiy	Quantity	Formation	Construction
SE¼ Sec. 13	60-400'	Hard	Good	----	Drilled
Sec. 17	117'	"	"	Gravel	Driven
NW¼ Sec. 28	70-100'	"	"	"	"
T32N-R9E Sec. 12	25'	"	"	"	"
SE¼ T30N-R9E Sec. 15	40'	Soft	"	"	Drilled
Sec. 28	20'	"	"	"	Driven
NW¼ Sec. 29	15'	"	"	"	"
NE¼ Sec. 29	30'	"	"	"	"
SE¼ Sec. 28	100'	Hard	"	Limestone	Drilled
NW¼ Sec. 29	100'	"	"	"	"
SW¼ Sec. 7	60'	Soft	"	Gravel	"
Sec. 7	60'	"	"	"	"
Sec. 18	30-70'	"	"	"	"
T30N-R8E Sec. 13	127'	Soft	Good	Gravel	Drilled
SW¼ Sec. 13	10-15	"	Fair	"	Driven--flowing &spr
SE¼ Sec. 24	20'	"	"	"	"
NE¼ Sec. 14	190'	Hard	Good	"	Drilled
SW¼ Sec. 26	210'	"	"	"	"
NW¼ Sec. 15	87'	"	"	"	"
NW¼ --------	35-60'	Soft	"	"	"
T31N-R8E Sec. 21	75'	Hard	"	Sand	"
NE¼ T32N-R8E Sec. 32	70'	"	"	"	"
NW¼					

Public Water Supplies of Several Larger Indiana Cities ( ).

( ) Collins, W.D. -- The Industrial Utility of Public Water Supplies in the United States, Water-Supply Paper 496, pp. 34-3[illegible]

No. Description.

64 Anderson (39,804); municipal; White River, filtered. The composition of the water is fairly uniform throughout the year. Analyzed by Margaret D. Foster, U. S. Geological Survey, Feb. 27, 1922.

65 East Chicago (54,784); East Chicago & Indiana Harbor Water Co., controlled by Indianapolis Water Co., Lake Michigan; filtered. Average of monthly analyses for two years made by

Indianapolis Water Company.

66 Evansville (102,249); municipal; Ohio River, filtered. Ananlyses from laboratory of filtration plant; monthly averages, published in annual report of city of Evansville for 1920.

67 Fort Wayne (114,946); municipal; wells 150 to 270 feet deep. Analyzed by C.H. Hurd, Indianapolis, Ind., for Fort Wayne Waterworks, Jan. 8, 1919. A, Sample from Pumping Station No. 1, B, Sample from Pumping Station No. 2.

68 Gary (100,426); Gary Heat, Light & Water Co., Lake Michigan. The water is practically the same as the supply for East Chicago. (See East Chicago).

69 Hammond (64,560); municipal; Lake Michigan; filtered. The water is practically the same as the supply for East Chicago. (See East Chicago.)

70 Indianapolis (364,161); Indianapolis Water Company; White River; filtered without coagulation (85 to 88 per cent ofsupply); wells (12 to 15 per cent of supply). Analyzed by Indianapolis Water Company. A, Average of analyses of composites of daily samples of filtered water over a period of 7 years. B, Average of analyses of composites of daily samples from Fall Creek station wells over a period of 2 years.

71 Kokomo (32,843); Kokomo Waterworks Co. (controlled by American Waterworks & Electric Co., 50 Broad Street, New York, N.Y.); wells 130 and 150 feet deep. Analyzed by Dearborn Chemical Co., Chicago, Ill., Aug. 19, 1921.

72 Muncie (46,548); Muncie Waterworks Co. (Controlled by American Waterworks & Electric Co., 50 Broad Street, New York, N.Y.); White River, filtered. Records over a period of several years show variations in alkalinity of 150 to 300 parts per million. The average analysis given for filtered water at Indianapolis may be taken as fairly representative of the average composition of the water at Muncie. (See analysis A, Indianapolis).

73 Richmond (32,493); Richmond City Waterworks (private company). Infiltration galleries. Analysis furnished by Richmond City Waterworks, Jan. 9, 1922.

74 South Bend (104,193); municipal; wells about 100 feet deep. Analyses by U.S. Geological Survey, October, 1907 (Water-Supply Paper 254, p.214). A, Sample from central station. B, Sample from north station.

75 Terre Haute (62,810); Terre Haute Waterworks Co.,; Wabash River, filtered. Analyses furnished by Terre Haute Waterworks Co., 1920; based on monthly composities of daily samples collected during 1920.

ANALYSES
(Parts per million)

	Total Dissolved Solids	Loss on Ignition	Silica (SiO_2)	Iron (Fe.)	Calcium (Ca.)	Magnesium (Mg.)	Sodium and Potassium (Na & K)	Bicarbonate radicle (HCO_3)	Sulphate radicle (SO_4)	Chloride radicle (Cl)	Nitrate radicle NO_5	Total hardness as ($CaCO_3$) Calculated	Number
	348	12	7.0	.17	72	29	N 5.1 K 2.0	262	72	20	11	299	64
	---	--	---	---	44	14	5	189	15	5.3	5.0	167	65
Avg	188	--	---	---	--	8.5	---	71	--	19	---	110	66
Max	---	--	---	---	--	16	---	101	--	30	---	169	66
Min.	---	--	---	---	--	3.7	---	48	--	14	---	82	66
A	528	--	---	.2	83	43	35	399	118	8	--	384	67
B.	506	--	---	.01	67	63	31	380	167	6	--	426	67
---	---	--	---	---	--	--	---	---	--	---	---	---	68
---	---	--	---	---	--	--	---	---	--	---	---	---	69
A	342	--	7.3	.31	72	27	13	275	58	20	5.8	291	70
B	361	--	14	1.2	74	32	16	380	29	6.5	.3	316	70
---	465	6.5	11	5.9	59	25	68	133	150	28	--	250	71
---	---	--	---	---	--	--	---	---	---	---	---	---	72
---	538	--	1.7	0.3	88	27	7.6	320	54	3.0	29	331	73
A	405	--	13	0.4	88	29	16	294	78	18.0	3.2	339	74
B	242	--	14	3.0*	45	22	7.7	222	25	3.2	.0	203	74
---	---	--	18	2.0*	78	26	6.9	290	85	---	---	280	75
---	---	--	14	Tr.*	87	38	4.4	141	71	12	---	241	75
Min.	284	--	18	---	44	18	---	---	---	8	---	184	75

*Aluminum and Iron

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